Design Manual

Signal Design Section

Part 1
Controller Terms

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NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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<td>Call Detector</td>
<td>Place Call During Phase</td>
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<td>Maximum Gap</td>
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</table>
Standard NEMA Orientation
Dual Ring Cabinet

Determine main street phase 2 (see sheet 2) and then proceed numbering clockwise.

Sum of phases for each major street approach is 7. 
(1+6=7 and 2+5=7)

Sum of phases for each minor street approach is 11. 
(3+8=11 and 4+7=11)

Standard NEMA Orientation
Single Ring 4 Phase Cabinet

Numbering of NEMA Phases

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

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STD. NO. 2.0
SHEET 1 OF 4
Phase Numbering

Phase 2 - Eastbound through movement
Phase 4 - Southbound through movement
Phase 6 - Westbound through movement
Phase B - Northbound through movement

Pair turning movements with the through movements
if an exclusive left turn phase (protected or protected/permissive) is not used.

If location is being added to an existing system, match phase numbering to the system.
Determining Movement Phase Numbers

Tee Intersections

<table>
<thead>
<tr>
<th>Phase Numbering</th>
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<td>Movement numbering will conform to standard NEMA phasing shown on Sheet 1.</td>
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<tr>
<td>Phase 2 - Eastbound or Northbound through movement</td>
</tr>
<tr>
<td>Phase 4 - Southbound or Eastbound Stem of Tee movement</td>
</tr>
<tr>
<td>Phase 6 - Westbound or Southbound through movement</td>
</tr>
<tr>
<td>Phase 8 - Northbound or Westbound Stem of Tee movement</td>
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NOTE: For 2070 SE-PAC, there must be a phase in Ring 1 for phase 2 to operate. This means that there must be a phase 2 for phase 6 to operate and there must be a phase 4 if using phase 8. For Tee intersections on SE-PAC use phase 4 for the stem of the Tee.

Determining Movement Phase Numbers

Split Side Streets

<table>
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<tr>
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<td>Main street movement numbering will conform to standard NEMA phasing shown on Sheet 1.</td>
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<tr>
<td>For side street movement numbering:</td>
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<tr>
<td>- If one approach is desired to be serviced first, label it phase 3 and the other approach phase 4.</td>
</tr>
<tr>
<td>- If there is no desire for either approach to be serviced first, label phase 4 for the eastbound or southbound movement and phase 3 for the westbound or northbound movement.</td>
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Numbering of NEMA Phases

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

12-10
Determining Superstreet Phase Numbers

Cross Intersections w/"Leftovers"

Phase Numbering
Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1.

For left turn and side street movement numbering:
- Phase should be an odd number on the opposite side of NEMA barrier (3 or 7).
- Sum of phases used at a superstreet signal should total 9 (2+7=9 or 3+6=9).
- At a cross, each "pair" of movements should be controlled by separate controllers and cabinets to facilitate system coordination.

Determining Superstreet Phase Numbers
U-Turn Only, Tee, or Unsignalized Right Turns

Phase Numbering
Main street through movement numbering will conform to standard NEMA phasing shown on Sheet 1.

No signal heads needed for through movement adjacent to left turn movement if there is no signalized conflicting movement.

For left turn movement numbering:
- Phase should be an odd number on the opposite side of NEMA barrier (3 or 7).
- Sum of phases used at a superstreet signal should total 9 (2+7=9 or 3+6=9).
- At a cross, each "pair" of movements should be controlled by separate controllers and cabinets to facilitate system coordination.

Numbering of NEMA Phases

7-09

STD. NO. 2.0

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

SHEET 4 OF 4
# 2-Phase

## Dual-Ring Cabinet

### PHASING DIAGRAM

```
\[ \text{Diagram showing signal layout and phasing} \]
```

### TABLE OF OPERATION

<table>
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<th>PHASE</th>
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<td>0 2+6</td>
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Note: Traffic movements are shown for illustrative purposes only.

---

**Phasing Typical: 2-Phase Operation**

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation
3-Phase
Minimum Recall
Protected or Protected/Permissive
at Cross Intersection
Dual-Ring Cabinet

PHASING DIAGRAM

PHASE PHASE SIGNAL SIGNAL

SIGNAL FACE PHASE SIGNAL FACE

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Use appropriate omit note(s).

Phasing Typical: 3-Phase Operation

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.2

SHEET 1 OF 2
3-Phase
Minimum Recall
Split-Side Street
Dual-Ring Cabinet

PHASING DIAGRAM

TABLE OF OPERATION

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NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

3-Phase
Minimum Recall
Lagging Left Operation
Protected or Protected/Permissive at Tee Intersection
Dual-Ring Cabinet

PHASING DIAGRAM

TABLE OF OPERATION

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NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

PhasingTypicals: 3-Phase Operation

Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

STD. NO. 2.1.2

Sheet 2 of 2
### 4-Phase Minimum Recall

- **Protected/Permissive Main Street**
- **Split-Side Street**
- **Dual-Ring Cabinet**

#### TABLE OF OPERATION

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<th>SIGNAL FACE</th>
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#### PHASING DIAGRAM

- **02+6**
- **03**
- **04**
- **02+5 (or 01+6)**

### 4-Phase Minimum Recall

- **Protected/Permissive Main Street**
- **Protected/Permissive Side Street**
- **Dual-Ring Cabinet**

#### TABLE OF OPERATION

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#### PHASING DIAGRAM

- **02+6**
- **03+8 (or 04+7)**
- **02+5 (or 01+6)**
- **04+8**

---

**Note:** Traffic movements are shown for illustrative purposes only.
**4-Phase**

**Minimum Recall**

Protected Main Street

Split-Side Street

Dual-Ring Cabinet

**PHASING DIAGRAM**

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**TABLE OF OPERATION**

Use appropriate omit note(s)

**NOTE:** TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

---

**4-Phase**

**Minimum Recall**

Lead-Lag Operation

Dual-Ring Cabinet

**PHASING DIAGRAM**

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**TABLE OF OPERATION**

With older controllers, the phase numbering may need to be modified

**NOTE:** TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

---

**PhasingTypicals: 4-Phase Operation**

**Signals & Geometrics Section**

**Traffic Engineering and Safety Systems Branch**

**North Carolina Department of Transportation**

**7-04**
4-Phase
Soft Recall
Protected/Permissive Main Street
Split-Side Street
Dual-Ring Cabinet

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Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 4-Phase Operation

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04

STD. NO.
2.1.3

SHEET 3 OF 3
Phasing Typicals: 5-Phase Operation

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

Table of Operation

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Use appropriate omit note(s).

Note: Traffic movements are shown for illustrative purposes only.

STD. NO. 2.1.4
Sheet 1 of 2
5-Phase 5-Phase
Soft Recall
Protected

PHASING DIAGRAM

TABLE OF OPERATION

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With older controllers, the phase numbering may need to be modified.

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 5-Phase Operation

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04
6-Phase
Minimum Recall
Protected/Permissive Main Street
Split Side Street

PHASING DIAGRAM

TABLE OF OPERATION

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Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

---

6-Phase
Minimum Recall
Protected/Permissive Main Street
Protected/Permissive Side Street

PHASING DIAGRAM

TABLE OF OPERATION

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Use appropriate omit note(s)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

---

Phasing Typicals: 6-Phase Operation

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.5

SHEET 1 OF 3
PHASING DIAGRAM

6-Phase
Soft Recall
Protected Main Street
Split Side Street

PHASING DIAGRAM

6-Phase
Soft Recall
Protected Main Street
Protected/Permissive Side Street

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NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Use appropriate omit note(s)

PHASING TYPICALS: 6-PHASE OPERATION

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.5

SHEET 3 OF 3
7-Phase Minimum Recall Lead-Lag Main Street

PHASING DIAGRAM

7-Phase Minimum Recall Lead-Lag Side Street

PHASING DIAGRAM

TABLE OF OPERATION

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With older controllers, the phase numbering may need to be modified.

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

PhasingTypicals: 7-Phase Operation

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.1.6
SHEET 1 OF 1
Phasing Typicals: 8-Phase Operation

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

8-Phase Minimum Recall
Protected/Permissive Main Street
Protected/Permissive Side Street

**PHASING DIAGRAM**

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<tr>
<th>SIGNAL FACE</th>
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<th>02+6</th>
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Use appropriate omit note(s)

**NOTE:** TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY
Phasing Typicals: 8–Phase Operation

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

8–Phase
Minimum Recall
Protected Main Street
Protected/Permissive Side Street

PHASING DIAGRAM

02+5
03+6
03+7
01+6
01+5
04+7
04+8

TABLE OF OPERATION

<table>
<thead>
<tr>
<th>SIGNAL FACE</th>
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NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.

8–Phase
Minimum Recall
Protected Main Street
Protected Side Street

PHASING DIAGRAM

02+5
03+6
03+7
01+6
01+5
04+7
04+8

TABLE OF OPERATION

<table>
<thead>
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<th>SIGNAL FACE</th>
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NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY.
8-Phase
Minimum Recall
Protected and Protected/Permissive Main Street
Protected and Protected/Permissive Side Street

PHASING DIAGRAM

Use appropriate omit note(s).

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

8-Phase
Soft Recall
Protected Main Street
Protected Side Street

PHASING DIAGRAM

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typicals: 8-Phase Operation

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

704
The use of Dallas Phasing is prohibited in the 2009 MUTCD.

This page has been removed from the Design Manual.
Red Revert Backup Protection

Yellow Trap and Dynamic Backup Control

A "yellow trap" occurs when a traffic signal cycles directly from concurrent through phases to a fully protected phase opposing a permitted phase (also known as "backing up"). This situation is avoided in a signal design whenever possible. Typically, phase omits or forcing the signal to cycle through the side street (even if there are no vehicle calls) to serve the protected phase have been used to protect against a "yellow trap."

Red Revert

Red revert is a feature in 2070 Oasis software that allows the signal to cycle from a permissive left turn phase on the major street to a protected phase and avoid a "yellow trap." Red revert simulates an all red "dummy" phase by clearing the through phase(s) to red for a brief interval before cycling to the adjacent protected left turn phase and then returning to green again; the opposing through phase will stay red for the duration of the protected turning phase.

The time that the adjacent through phase displays red before returning to green is a function of the red revert time. Typically the red revert time is programmed to (at least) 5 seconds to avoid the appearance of improper operation.

Conditions for Use

1. Used only with 2070 Oasis Software
2. Cannot be used with NEMA TS-1, TS-2, 170, or other 2070 software (such as SE-PAC, NAZTEC, or the Cary Signal System)
3. Used only on the major street (phases 2+6)
4. May be used when there is one or two protected/permissive phases (1 and/or 5) on the major street
5. Use in conjunction with 5 section (doghouse) heads.
6. Use in place of phase omit and clearing through the side street.
7. Do NOT use with Railroad Preemption if the major street is the approach that crosses the tracks and is used in the Track Clearance Phase.

When Used On Plans:

-Typically set red revert time for phase 2 (and/or 6) to 5.0 seconds.
-Default red revert time for all other phases is 2.0 seconds.
-Use the following note on plans:
  Enable backup protect for phase 2 (and/or 6) to allow the controller to clear from phase 2+6 to phase 2+5 (and/or 1+6) by progressing though an all red display.

Phasing Typical: Red Revert Operation

<table>
<thead>
<tr>
<th>STD. NO.</th>
<th>2.3</th>
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<tr>
<td>SHEET 1 OF 3</td>
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</table>
3 Phase
Minimum Recall
Protected/Permissive Left One Direction
Permissive Only Left Other Direction

PHASING DIAGRAM

Use Red Revert for Phase 2 (6 if 1+6 is used)

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

4 Phase
Minimum Recall
Protected/Permissive Left One Direction of Major Street
Permissive Left on Other Direction of Major Street
Protected/Permissive Side Street
OR Split Side Street

PHASING DIAGRAM

Use Red Revert for Phase 2 (6 if 1+6 is used)
Use appropriate omit note(s) for side street

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

Phasing Typical: Red Revert Operation

TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
5-B Phase
Minimum Recall
Protected/Permissive Main Street w/Red Revert

PHASING DIAGRAM

To Side
Street Phasing

Ø2+6

Ø2+5

Ø1+6

Ø1+5

From Side
Street Phasing

NOTE: ONLY PHASING DIAGRAM
FOR MAJOR IS SHOWN. FOR
SIDE STREET PHASING, SEE
APPROPRIATE PHASING IN
STD. 2.1.

Use Red Revert for Phases 2 and 6
Use appropriate omit or lead/lag
note(s) for side street as needed

NOTE: TRAFFIC MOVEMENTS ARE
SHOWN FOR ILLUSTRATIVE
PURPOSES ONLY

Phasing Typical: Red Revert Operation

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 2.3

7-09

SHEET 3 OF 3
3 Phase
Minimum Recall
Protected/Permissive Left One Direction
Permissive Only Left Other Direction

PHASING DIAGRAM

Phase 5 may be logged (Phase 1 if 1+6 is used)

This assumes a 4 section FYA is used for the left turn
on one approach (Phase 5) and a 3 section FYA is used
for the left turn on the other approach of Main Street.

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

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<td>61</td>
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4 Phase
Minimum Recall
Protected/Permissive Left One Direction of Main Street
Permissive Left on Other Direction of Main Street
Protected/Permissive Side Street
OR Split Side Street

PHASING DIAGRAM

Phase 5 may be logged (Phase 1 if 1+6 is used)

This assumes a 4 section FYA is used for the left turn
on one approach (Phase 5) and a 3 section FYA is used
for the left turn on the other approach of Main Street.

NOTE: TRAFFIC MOVEMENTS ARE SHOWN FOR ILLUSTRATIVE PURPOSES ONLY

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Phasing Typical: Flashing Yellow Arrow

Signal Design Section
Transportation Mobility and Safety Division
North Carolina Department of Transportation

STD. NO.

12-10

2.4 SHEET 1 OF 2
5-8 Phase
Minimum Recall
Protected/Permissive Main Street

This assumes a 4 section FYA is used for the left turn on both approaches of the main street.

Note: only phasing diagram for major is shown. For side street phasing, see appropriate phasing in Std. 2.1.

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Use lead/lag notes for Phases 1 and 5. Use appropriate omni or lead/lag note(s) for side street as needed.

Note: traffic movements are shown for illustrative purposes only.

Phasing Typicals: Flashing Yellow Arrow

Signal Design Section
Transportation Mobility and Safety Division
North Carolina Department of Transportation
Typically signal heads are labeled according to their right-of-way phase (first digit) and from inside to outside (second digit). Five section heads are labeled according to their permissive phase.

* If signal head 41 is not used or not required, it may be omitted. The left turn would be controlled by the shared green balls of the through movement. Signal heads 42 and 43 should then be heads 41 and 42, respectively.
Signal Head Types

### CONFIGURATION

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### USAGE

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<th>Protected Turn</th>
<th>Split Side Street RR Clearance Phasing EV Preempt Phasing</th>
<th>Protected/Permissive Turn</th>
<th>Protected/Permissive Turn</th>
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<td>Protected Turn</td>
<td>Split Side Street RR Clearance Phasing EV Preempt Phasing</td>
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### Number of Signal Faces

A minimum of two signal faces is required for the through movement. This total includes the through signal face belonging to the 5-section "shared" head that may control adjacent left or right turn lanes.

Clarification: A 5-section head is an assembly of 2 signal faces which share a common red ball indication. See example below.

This approach display has 2 signal heads each of which is comprised of 2 signal faces for a total of 4 signal faces. Two of the faces belong to the through move, and one each belongs to the left and right turns. Because the center two faces control the through (major) move, it is in conformance with the above requirement.

Per Section 4D.11 of the 2009 MUTCD, if the 85th percentile, posted, statutory, or design speed is 45 MPH or more, one signal head should be used per each through lane on the approach.

### General Guidelines for Signal Head Usage

**SIGNAL DESIGN SECTION**

**TRANSPORTATION MOBILITY AND SAFETY DIVISION**

**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**

**STD. NO.**

12-10
Use of CIRCULAR RED vs. RED ARROW
(Section 4D.04 of the 2009 MUTCD)

As stated in the MUTCD, and in accordance with NC General Statute 20-158, vehicles facing a steady CIRCULAR RED signal shall stop at the marked stop line and shall remain stopped until a signal indication to proceed is displayed unless the vehicle is turning right. A vehicle is permitted to make a right on CIRCULAR RED, subject to applicable traffic laws and yielding the right of way to other roadway users, unless a traffic control device, such as a sign, is in place prohibiting a turn on red.

As stated in the MUTCD, vehicles facing a steady RED ARROW signal shall stop at the marked stop line and shall remain stopped until a signal indication to proceed is displayed. A vehicle shall NOT make a right turn on a RED ARROW.

In North Carolina, vehicles are prohibited from making a left turn on red from a one way street onto another one way street at all times.

It shall be the NCDOT practice to display a CIRCULAR RED whenever possible and allow right turns on red. This may include the use of a CIRCULAR RED indication in a head otherwise containing GREEN and YELLOW ARROWS.

If it is intended to prohibit right turns on red at an intersection, one of the following shall be displayed:

- If the signal head contains CIRCULAR YELLOW and GREENs, a CIRCULAR RED shall be used in conjunction with a "NO TURN ON RED" sign (R10-16).

- If the signal head only has YELLOW and GREEN ARROWS, a RED ARROW shall be used. No sign is needed as a RED ARROW means no turn on red.
**Use of 4 Section (Protected/Permissive) Flashing Yellow Arrow Signal Faces**

Traditionally, a 5 section "doghouse" head has been used for protected/permissive turning movements. This head has a combination of CIRCULAR and ARROW displays, and is often used as "shared" head between the turning movement and the through movement, although the head could be used exclusively for the turning movement.

The new preferred display for protected/permissive left turns is the Flashing Yellow Arrow (FYA). This head is intended to be an exclusive head for the turn lane and displays only ARROW indications. A FYA is displayed for the permissive movement, instead of the traditional CIRCULAR GREEN. Vehicles may make the turn indicated by the FYA after yielding to pedestrians and conflicting movements. A solid GREEN ARROW is used to indicated a protected movement. The FYA head should be centered over the turn lane(s). Note that the FYA head is an exclusive for the left turn, and 2 signal heads containing CIRCULAR RED, YELLOW, and GREEN displays are still required for the through movement.

This approach display has 2 signal heads each of which is comprised of 2 signal faces for a total of 4 signal faces. Two of the faces belong to the through move, and one each belongs to the left and right turns. Because the center two faces control the through (major) move, it is in conformance with the requirement for 2 signal faces for the through movement. The 5 section head may still be used in limited situations.

FYAs for left turns should be used:
- When the turn lanes are offset (separated from the through lanes)
- When the opposing travel lanes use (3-section or 4-section) FYAs or fully protected (single or dual) lefts to avoid "yellow trap"
- Along corridors, where other FYA displays are used for left turns
- At Railroad preempt locations, which eliminate the need for blankout signs

When FYAs are used for left turns, the yellow and red clearance times should be the same for concurrent through phases (2+6 and/or 4+8).

**NOTE:** FYAs for right turns may be used on a limited basis as determined by Engineering judgment. When used, the FYA head should replace the 5 section shared "doghouse" head for the right turn. As a result, it may be necessary to add an additional 3 section CIRCULAR head for the through movement.

---

**General Guidelines for Signal Head Usage**

**SIGNAL DESIGN SECTION**
**TRANSPORTATION MOBILITY AND SAFETY DIVISION**
**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**

**STD. NO. 3.0**
**SHEET 4 OF 6**
Use of 3-Section (Permissive) Left Turn Flashing Yellow Arrow Signal Faces

Traditionally, a CIRCULAR GREEN display has been used to indicate a permissive movement. Vehicles may turn right or left as allowed on a CIRCULAR GREEN after yielding to pedestrians and conflicting movements.

A CIRCULAR GREEN may be used as a shared display with the through movement. In the example shown, the signal heads are mounted over the lane lines (extended) and are classified as shared heads, because the head display is "shared" by vehicles in adjacent lanes (left and through or the through and through-right). The two "shared" heads meet the requirements for through signal displays. When an FYA is not used for the left turn display, the signal heads should be mounted over the lane line extended instead of as shown in Std. 3.2. IN NO CASE shall a CIRCULAR GREEN display be located directly over or in front of a left turn lane.

Optional Permissive Left Turn Signal Display

An optional display for permissive turns is the Flashing Yellow Arrow (FYA). Vehicles observing an FYA may make the turn indicated by the flashing yellow arrow after yielding to pedestrians and conflicting movements, the same as a CIRCULAR GREEN. The FYA head should be centered over the turn lane(s). Note that the FYA is an exclusive head for the left turn, and 2 signal heads containing CIRCULAR RED, YELLOW, and GREEN displays are still required for the through movement.

FYAs for left turns should be used:
- When the turn lanes are offset (separated from the through lanes)
- When the opposing travel lanes use (3-section or 4-section) FYAs or fully protected (single or dual) lefts to avoid "yellow trap"
- Along corridors, where other FYA displays are used for left turns
- At Railroad preempt locations, which eliminate the need for blankout signs

When FYAs are used for left turns, the yellow and red clearance times should be the same for concurrent through phases (2+6 and/or 4+8).

FYAs for right turns may be used on a limited basis as determined by Engineering judgment.
Programming for Flashing Operation of Signal Heads

Signals typically may flash during certain types of malfunctions or equipment failures. For statewide consistency, traffic signal heads should be set to flash the displays shown in the event of flashing operation:

<table>
<thead>
<tr>
<th>SIGNAL HEAD</th>
<th>MAJOR STREET</th>
<th>MINOR STREET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>← R</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>← Y</td>
<td>← R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>R</td>
</tr>
</tbody>
</table>

Flashing display does not change if a RED ARROW is used in place of a CIRCULAR RED for right turn displays.

At some intersections, such as those utilizing Railroad Preemption, engineering judgement may be used to modify or alter the flashing operation. This modification may include flashing the minor street through movements yellow and the main street red or using a red flash on all approaches (equivalent of an all way stop).

Program all signal heads on the same approach to flash concurrently.
Allowable Signal Head Distance from Stopbar

(Section 4D.14 of the 2009 MUTCD)

NOTE: All signal heads shall be 12" indications unless they meet the Option requirements of Section 4D.07 of the 2009 MUTCD.

NOTE: Where the nearest signal face is located between 150 and 180 ft (45 and 55 m) beyond the stop line, use engineering judgement to determine if a near side signal head would be beneficial.

MUTCD Requirements for Signal Heads

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
To conform to section 4D.13 of the 2009 MUTCD, locate one, and preferably both, signal heads within a cone of vision extending 20 degrees to the left and right of the centerline of all the approach lanes in the direction of travel.

To conform to section 4D.12 of the 2009 MUTCD, the driver should be able to continuously view the signal face from the minimum sight distance for the 85th percentile speed.

Where this visibility requirement cannot be met, erect a suitable sign (such as a Signal Ahead Sign) to warn approaching traffic (Section 4D.12 of the 2009 MUTCD) or install a supplemental near side head.

### Signal Face Visibility Parameters

<table>
<thead>
<tr>
<th>Speed mph (km/hr)</th>
<th>Min. Sight Distance X ft (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 (32)</td>
<td>175 (55)</td>
</tr>
<tr>
<td>25 (40)</td>
<td>215 (65)</td>
</tr>
<tr>
<td>30 (48)</td>
<td>270 (85)</td>
</tr>
<tr>
<td>35 (56)</td>
<td>325 (100)</td>
</tr>
<tr>
<td>40 (64)</td>
<td>390 (120)</td>
</tr>
<tr>
<td>45 (72)</td>
<td>460 (140)</td>
</tr>
<tr>
<td>50 (80)</td>
<td>540 (165)</td>
</tr>
<tr>
<td>55 (88)</td>
<td>625 (195)</td>
</tr>
<tr>
<td>60 (96)</td>
<td>715 (220)</td>
</tr>
</tbody>
</table>
CASE 1
Standard Main or Side Street Signal Head Configuration

1A - Permissive Only

1B - Protected/Permissive Left Turn

CASE 2
Standard Main or Side Street Signal Head Configuration

2A - Permissive Only Left Turn
* Optional Head

2B - Protected/Permissive Left Turn

2C - Protected Left Turn

Signal Head Approach Displays and Alignment
CASE 3 (1 OF 2)
Standard Main or Side Street Signal Head Configuration

3A - Permissive Only Left Turn

3AR - Permissive Only Left Turn with Right Turn Overlap

8 ft min.

CASE 3 (2 OF 2)
Standard Main or Side Street Signal Head Configuration

3B - Protected/Permissive Left Turn

3BR - Protected/Permissive Left Turn with Right Turn Overlap

8 ft min.
CASE 5 (2 OF 3)
Standard Main or Side Street Signal Head Configuration

5B - Protected/Permissive Left Turn

5BR - Protected/Permissive Left Turn with Right Turn Overlap

CASE 5 (3 OF 3)
Standard Main or Side Street Signal Head Configuration

5C - Protected Left Turn

5CR - Protected Left Turn with Right Turn Overlap

Signal Head Approach Displays and Alignment

STANDARD NO. 3.2
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

12-10
### CASE 6
Standard Main or Side Street
Signal Head Configuration

- **6A** - Permissive Only Left Turn
  - *Optional Head

- **6B** - Protected/Permissive Left Turn

- **6C** - Protected Left Turn

### CASE 7 (1 OF 3)
Standard Main or Side Street
Signal Head Configuration

- **7A** - Permissive Only Left Turn
  - *Optional Head
  - If not used, a 3 section CIRCULAR head may be added on the lane line

- **7AR** - Permissive Only Left Turn
  - With Right Turn Overlap
CASE 7 (2 of 3)
Standard Main or Side Street
Signal Head Configuration

7B - Protected/Permissive Left Turn

7BR - Protected/Permissive Left Turn with Right Turn Overlap

CASE 7 (3 OF 3)
Standard Main or Side Street
Signal Head Configuration

7C - Protected Left Turn

7CR - Protected Left Turn with Right Turn Overlap

Signal Head Approach Displays and Alignment
CASE 8 (1 OF 2)  
(Speeds less than 45 MPH)  
Standard Main or Side Street  
Signal Head Configuration

8A - Permissive Only  
Left Turn  
* Optional Head

8B - Protected/Permissive  
Left Turn

8C - Protected  
Left Turn

CASE 8 (2 OF 2)  
(Speeds 45 MPH or above)  
Standard Main or Side Street  
Signal Head Configuration

8A45 - Permissive Only  
Left Turn  
* Optional Head

8B45 - Protected/Permissive  
Left Turn

8C45 - Protected  
Left Turn
CASE 9 (1 OF 3)
Standard Main or Side Street
Signal Head Configuration

9A - Permissive
Left Turn
* Optional Head

9AR - Permissive
Left Turn
with Right
Turn Overlap
* Optional Head

CASE 9 (2 OF 3)
Standard Main or Side Street
Signal Head Configuration

9B - Protected/
Permissive
Left Turn

9BR - Protected/
Permissive
Left Turn
with Right
Turn Overlap
CASE 9 (3 OF 3)
Standard Main or Side Street Signal Head Configuration

9C - Protected Left Turn

9CR - Protected Left Turn with Right Turn Overlap

CASE 10 (1 OF 2)
(Speeds less than 45 MPH)
Standard Main or Side Street Signal Head Configuration

10A - Permissive Left Turn
* Optional Head

10B - Protected/Permissive Left Turn

10C - Protected Left Turn

Signal Head Approach Displays and Alignment
CASE 10 (2 OF 2)
(Speeds 45 MPH or above)
Standard Main or Side Street
Signal Head Configuration

10A45 - Permissive
Left Turn
* Optional Head

10B45 - Protected/
Permissive
Left Turn

10C45 - Protected
Left Turn

CASE 11
Main or Side Street
Signal Head Configuration
for Dual Left Turn Movements

11A - Protected/
Permissive
Left Turn

8 ft min.

11B - Protected
Left Turn

8 ft min.

Signal Head Approach Displays and Alignment

12-10
CASE 12
Main or Side Street
Signal Head Configuration
for Dual Left Turn Movements

12A - Protected/Permissive Left Turn
12B - Protected Left Turn

For thru and right lane signal heads, see corresponding diagram for exclusive left turns (Cases 5-10)

CASE 13 (1 OF 2)
Main or Side Street
Signal Head Configuration
for Dual Right Turn Movements

13A - Permissive Left,
No Right Turn
Overlap, with Signs

13AP - Permissive Left,
No Right Turn
Overlap, with Peds, No Signs
CASE 13 (2 of 2)
Main or Side Street
Signal Head Configuration
for Dual Right Turn Movements

13AR - with Right
Turn Overlap
No Crosswalks
or Ped Heads

13ARP - with Right
Turn Overlap
With Crosswalks
and/or Ped Heads

CASE 14
Main or Side Street
Signal Head Configuration
for Dual Right Turn Movements

14A - without Right
Turn Overlap,
with Peds,
Opposing
Permitted Left

14B - with Right
Turn Overlap,
with Peds,
Opposing
Permitted Left

14C - with or
without
Overlap,
No Peds,
Opposing
Protected Left

Signal Head Approach Displays and Alignment

STANDARD NO.

12-10
CASE 15

Stem of “Tee” Intersection or
Ramp Terminal or
One-Way Situation
Signal Head Configuration

15A - No Right Turn Overlap

15AR - with Right Turn Overlap

CASE 16

Stem of “Tee” Intersection or
Ramp Terminal or
One-Way Situation
Signal Head Configuration

Signal Head Approach Displays and Alignment
CASE 17
Stem of “Tee” Intersection or Ramp Terminal or One-Way Situation
Signal Head Configuration

CASE 18
Stem of “Tee” Intersection or Ramp Terminal or One-Way Situation
Signal Head Configuration

18A - No Right Turn Overlap

18AR - with Right Turn Overlap

18AS - No Signs, with or without Overlap, without Peds

Signal Head Approach Displays and Alignment

12-10

STANDARD NO.
3.2

SHEET 14 OF 24
CASE 19
Stem of “Tee” Intersection or Ramp Terminal or One-Way Situation
Signal Head Configuration

19A - No Right Turn Overlap

19AR - with Right Turn Overlap, With Peds

19AS - No Signs, with or without Overlap, No Peds

CASE 20
Stem of “Tee” Intersection or Ramp Terminal or One-Way Situation
Signal Head Configuration

20A - No Right Turn Overlap, with Signs

20AP - No Signs, with or without Overlap, with Peds

20AS - No Signs, with or without Overlap, No Peds
CASE 21
Split Phasing
Signal Head Configuration

CASE 22
Split Phasing
Signal Head Configuration

Signal Head Approach Displays and Alignment

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 3.2
SHEET 16 OF 24
CASE 23
Split Phasing
Signal Head Configuration

23C - No Right Turn Overlap

23CR - with Right Turn Overlap

CASE 24
Split Phasing
Signal Head Configuration

Signal Head Approach Displays and Alignment
CASE 25
Split Phasing
Signal Head Configuration

CASE 26
Split Phasing
Signal Head Configuration
CASE 27
Split Phasing
Signal Head Configuration

27C - No Right Turn Overlap

27CR - with Right Turn Overlap

CASE 28
Split Phasing
Signal Head Configuration

Signal Head Approach Displays and Alignment

12-10
CASE 29
Split Phasing
Signal Head Configuration

29C - No Right Turn Overlap

29CR - with Right Turn Overlap

CASE 30
Split Phasing
Signal Head Configuration

Signal Head Approach Displays and Alignment

Signal Design Section
Transportation Mobility and Safety Division
North Carolina Department of Transportation
CASE 31 (1 OF 2)
Split Phasing
Signal Head Configuration

31C - with Signs, No Right Turn Overlap

31CS - without Signs, No Right Turn Overlap

CASE 31 (2 OF 2)
Split Phasing
Signal Head Configuration

31CR - with Signs, with Right Turn Overlap

31CRS - without Signs, with Right Turn Overlap

Signal Head Approach Displays and Alignment
CASE 32
Split Phasing
Signal Head Configuration

32A - with Signs

32AS - without Signs

CASE 33
Split Phasing
Signal Head Configuration
for Dual Right Turn Movements

33A - No Right Turn Overlap

33AR - with Right Turn Overlap
No Crosswalks or Ped Heads

33ARP - with Right Turn Overlap
with Crosswalks and/or Ped Heads

Signal Head Approach Displays and Alignment
**CASE 34**

**Split Phasing**

**Signal Head Configuration**

34C - No Right Turn Overlap

34CR - with Right Turn Overlap

**CASE 35**

**Split Phasing**

**Signal Head Configuration**

35C - No Right Turn Overlap

35CR - with Right Turn Overlap

Signal Head Approach Displays and Alignment
CASE 36
Split Phasing
Signal Head Configuration

CASE 37
Split Phasing
Signal Head Configuration

36C - No Right Turn Overlap

36CR - with Right Turn Overlap

37C - No Right Turn Overlap

37CR - with Right Turn Overlap
Typically loops are labeled according to their right-of-way phase (number) and from inside to outside (letter) beginning with the loops farthest from the stop line. A protected/permissive loop is labeled according to its protected phase.

*Note- For some designs if the Phase 8 right turn is an overlap with Phase 1 (protected left phase of a protected/permissive move), this movement may call phase 1 directly (rather than phase 8) and Loop 8C should be numbered as Loop 1B.
Volume Density Operation

Design Speed
<table>
<thead>
<tr>
<th>mph (km/hr)</th>
<th>ft (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 (64)</td>
<td>250 (75)</td>
</tr>
<tr>
<td>45 (72)</td>
<td>300 (90)</td>
</tr>
<tr>
<td>50 (80)</td>
<td>355 (110)</td>
</tr>
<tr>
<td>55 (88)</td>
<td>420 (130)</td>
</tr>
</tbody>
</table>

L = 6ft x 6ft (1.8m x 1.8m)
- Presence loop
- Wired in series for TS1 Controllers
- Wired to separate detectors/channels for 170, TS2, and 2070 Controllers

Design Considerations:
- High speed [≥40 mph (64 km/hr)]
- Preferred option for cost and efficiency

Notes:
- Set vehicle call memory to "LOCK"
- Not appropriate for use with out-of-street detection
- Volume density loops can double as system detectors when wired separately.
Volume Density Operation with DCEC
(Delayed Call/Extended Call)

L1 = 6ft X 6ft (1.8m X 1.8m)
Presence loop
Wired in series for TS1 Controllers
Wired to separate detectors/channels
for 170, TS2, and 2070 Controllers

L2 = 6ft X 40ft
(1.8m X 12.0m)
Quadrupole loop
Wired to separate detectors/channels

Design Considerations:
· High speed [≥40 mph (64 km/hr)]
· High volume driveways between L1 and L2
· Single lane approach with left turns
· High truck traffic with steep positive grades
· Out-of-street detection
· More efficient than standard "stretch" detection, but costlier to install and maintain

<table>
<thead>
<tr>
<th>Design Speed mph (km/hr)</th>
<th>D (ft) (m)</th>
<th>L2 Delay sec</th>
<th>Extend sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 (64)</td>
<td>250 (75)</td>
<td>5.0</td>
<td>2.0</td>
</tr>
<tr>
<td>45 (72)</td>
<td>300 (90)</td>
<td>5.0</td>
<td>2.0</td>
</tr>
<tr>
<td>50 (80)</td>
<td>355 (110)</td>
<td>5.0</td>
<td>2.0</td>
</tr>
<tr>
<td>55 (88)</td>
<td>420 (130)</td>
<td>5.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Notes:
· Do not program "ACTUATIONS B4 ADD" (not applicable for 2070 controllers), "SEC. PER ACTUATION" and "MAX. INITIAL"
· Delay on loops L2 must be FULL TIME delay
· Do not program "Vehicle Call Memory" for phases 2 & 6
· Loops L1 can double as system detectors when wired separately

Loop Placement for Main Street Through Movements

Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation
Extend (Stretch) Detection

L1 = 6ft X 6ft
(1.8m X 1.8m)
Presence loop
Wired in series

L2 = 6ft X 6ft
(1.8m X 1.8m)
Presence loop
Wired in series

Design Considerations:
- High speed [≥40 mph (64 km/hr)]
- High volume driveways between L1 and L2

Notes:
- Appropriate for use with out-of-street detection
- Loops L1 can double as system detectors, IF wired to separate detectors/ channels
- Gap time typically 2.0 seconds
- For TS-1 controllers, round Extend time up to nearest 0.25 seconds
- Loop placement may be varied due to design constraints such as bridges or poor pavement, or non-standard placement of existing loops. In such cases, recalculate Extend times for L1.

\[
\text{Extend time (sec)} = \left( \frac{(D1-D2) \text{ feet}}{(\text{Design Speed -5} \text{ mph})} \times \frac{3600 \text{ sec/hr}}{5280 \text{ ft/mi}} \right) \times \text{- Gap time}
\]

Loop Placement for Main Street Through Movements

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>D1 (ft)</th>
<th>D2 (ft)</th>
<th>Extend (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 (64)</td>
<td>250 (75)</td>
<td>80 (25)</td>
<td>1.3</td>
</tr>
<tr>
<td>45 (72)</td>
<td>300 (90)</td>
<td>90 (27)</td>
<td>1.6</td>
</tr>
<tr>
<td>50 (80)</td>
<td>355 (110)</td>
<td>100 (30)</td>
<td>1.9</td>
</tr>
<tr>
<td>55 (88)</td>
<td>420 (130)</td>
<td>110 (35)</td>
<td>2.2</td>
</tr>
</tbody>
</table>
Low Speed Detection

L = 6ft X 6ft (1.8m X 1.8m)
Presence loop, wired in series

Design Considerations:
- Low speed [≤35 mph (56 km/hr)]
- Gap time typically 3.0 seconds
- Preferred option

L = 6ft X 40ft (1.8m X 12.0m)
Quadrupole loop, wired to separate detectors/channels

Design Considerations:
- Low speed [≤35 mph (56 km/hr)]
- Gap time typically 0-2 seconds
- Appropriate for use with soft recall

Loop Placement for Main Street Through Movements

Credits:
Presence Detector

L = 6ft X 40ft (1.8m X 12.0m) Quadrupole
or, if longer detection area is needed:
6ft X 50ft (1.8m X 15.0m) Quadrupole
or
6ft X 60ft (1.8m X 18.0m) Quadrupole

Notes:
- Loops may not be required for all main street permissive turns
- Option to use 6ft X 6ft (1.8m X 1.8m) loop to wire in series with 70’ through loops.

<table>
<thead>
<tr>
<th>Loop Type</th>
<th>Delay time</th>
<th>Full Time Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Turn Loop on Main Street</td>
<td>0 sec</td>
<td>N/A</td>
</tr>
<tr>
<td>with Low Speed or Stretch Detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Turn Loop on Main Street</td>
<td>3-5 sec</td>
<td>Yes</td>
</tr>
<tr>
<td>with Volume Density Detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Turn Loop on Side Street</td>
<td>2-3 sec if “clipping” prevention is</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>desired; 0 sec otherwise</td>
<td></td>
</tr>
</tbody>
</table>

Loop Placement for Permissive Left Turns

TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
Presence Loop with 2 Channel Detector

- - - - - - - - - - - - L

L = 6ft X 40ft (1.8m X 12.0m) Quadrupole loop

or, if longer detection area is needed:

6ft X 50ft (1.8m X 15.0m) Quadrupole loop

or

6ft X 60ft (1.8m X 18.0m) Quadrupole loop

Design Considerations:

- Facilitates upgrade to fully protected
  or downgrade from fully protected
- Calls up arrow when 1 or 2 cars
  waiting to turn
- Consider queue loop (Std. No. 4.1.3:2)
  for light left turn traffic or for light
  opposing through traffic

Note:
- Calling/ extending the permissive phase may
  not be required for main street loops
- Gap time typically 1-3 seconds

<table>
<thead>
<tr>
<th>Loop Type</th>
<th>Detector Channel</th>
<th>Phase</th>
<th>Delay Time</th>
<th>Full Time Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Turn Loop on Main Street</td>
<td>1</td>
<td>Protected Phase</td>
<td>10-30 sec</td>
<td>No</td>
</tr>
<tr>
<td>with Low Speed or Stretch Detection</td>
<td>2</td>
<td>Permissive Phase</td>
<td>0 sec</td>
<td>N/A</td>
</tr>
<tr>
<td>Left Turn Loop on Main Street</td>
<td>1</td>
<td>Protected Phase</td>
<td>10-30 sec</td>
<td>No</td>
</tr>
<tr>
<td>with Volume Density Detection</td>
<td>2</td>
<td>Permissive Phase</td>
<td>3-5 sec</td>
<td>Yes</td>
</tr>
<tr>
<td>Left Turn Loop on Side Street</td>
<td>1</td>
<td>Protected Phase</td>
<td>10-30 sec</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Permissive Phase</td>
<td>2-3 sec if &quot;clipping&quot; prevention is desired; 0 sec otherwise</td>
<td>No</td>
</tr>
</tbody>
</table>

Loop Placement for Protected/Permissive Left Turns

STD. NO. 4.1.3

5-05
Queue Detector Loop

L1 = 6ft X 15ft (1.8m X 4.5m)
Presence loop (Queue detector) with Call delay

L2 = 6ft X 40ft
(1.8m X 12.0m)
Quadrupole loop

Notes:
-L2 is optional when permitted
phase has minimum recall
-L1 min green typically 8 seconds
-L1 gap time typically 2-4 seconds
-L2 gap time typically 1-3 seconds

Design Consideration:
-Calls up arrow when 3 or more cars waiting to turn
-Consider for side street left turns

<table>
<thead>
<tr>
<th>Loop Type</th>
<th>Phase</th>
<th>Delay Time</th>
<th>Full Delay Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1:</td>
<td>Queue Detector</td>
<td>Protected Phase</td>
<td>5-15 sec</td>
</tr>
<tr>
<td>L2:</td>
<td>Left Turn Loop on Main Street</td>
<td>Permissive Phase</td>
<td>0 sec</td>
</tr>
<tr>
<td></td>
<td>with Low Speed or Stretch Detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2:</td>
<td>Left Turn Loop on Main Street</td>
<td>Permissive Phase</td>
<td>3-5 sec</td>
</tr>
<tr>
<td></td>
<td>with Volume Density Detection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2:</td>
<td>Left Turn Loop on Side Street</td>
<td>Permissive Phase</td>
<td>2-3 sec if &quot;clipping&quot; prevention is desired; 0 sec otherwise</td>
</tr>
</tbody>
</table>

Loop Placement for Protected/Permissive Left Turns

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

5-05
Presence Detector

L = 6ft X 40ft (1.8m X 12.0m) Quadrupole

or, if longer detection area is needed:

6ft X 50ft (1.8m X 15.0m) Quadrupole

or

6ft X 60ft (1.8m X 18.0m) Quadrupole

Notes:

- Gap time typically 1-3 seconds
- A short (2 or 3 sec) call delay may be used if turning vehicles are able to "clip" loop L
- If call delay is used, do not program full time delay
Typical Presence Detection

L = 6ft X 40ft (1.8m X 12.0m)
Quadrupole loop
Wired to separate detectors/channels

or, if longer detection area is needed:

6ft X 50ft (1.8m X 15.0m) Quadrupole
or
6ft X 60ft (1.8m X 18.0m) Quadrupole

Notes:
- Consider delay (NOT full time) if through lane is shared with a right-turn move, except where right turn on red is prohibited
- Gap time typically 1-3 seconds
- Consider higher gap time or longer detection area under the following circumstances:
  - Steep positive approach grade
  - High truck volumes
Volume Density Operation with DC/EC

(Delayed Call/Extended Call)

\[ L1 = 6\text{ft} \times 6\text{ft} \ (1.8\text{m} \times 1.8\text{m}) \] Presence loop
Wired in series for TS1 Controllers
Wired to separate detectors/channels
for 170, TS2, and 2070 Controllers

\[ L2 = 6\text{ft} \times 40\text{ft} \ (1.8\text{m} \times 12.0) \] Quadrupole loop
Wired to separate detectors/channels

<table>
<thead>
<tr>
<th>Design Speed ( \text{mph} ) ( \text{(km/hr)} )</th>
<th>( D ) ( \text{ft} ) ( \text{m} )</th>
<th>( L2 )</th>
<th>( \text{Delay} ) ( \text{sec} )</th>
<th>( \text{Extend} ) ( \text{sec} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 ( (64) )</td>
<td>250 ( (75) )</td>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>45 ( (72) )</td>
<td>300 ( (90) )</td>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>50 ( (80) )</td>
<td>355 ( (110) )</td>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>55 ( (88) )</td>
<td>420 ( (130) )</td>
<td>5.0</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Design Considerations:
- Cross intersection AND
- High speed \( \geq 40 \text{ mph} \ (64 \text{ km/hr}) \) AND
- Good horizontal and vertical alignment
- In some cases can provide better efficiency than "stretch" detection

Notes:
- Do not program "ACTUATIONS B4 ADD" (not applicable for 2070 controllers), "SEC. PER ACTUATION" and "MAX. INITIAL."
- Delay on loops \( L2 \) must be FULL TIME delay
- Do not program "Vehicle Call Memory" for phases 4 & 8.
- Loops \( L1 \) should be programmed for "EXTENSION" but NOT "CALLING."

- For TS2 controllers, loops \( L1 \) must be programmed with 100 second delay (INHIBIT DELAY DURING GREEN = YES) to ensure that the loop acts to extend the phase only.
- Loops \( L1 \) can double as system detectors if wired separately.

Loop Placement for Side Street Through Movements

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 4.1.5
SHEET 2 OF 3
Extend (Stretch) Detection

\[ L_1 = 6\text{ft} \times 6\text{ft} \ (1.8\text{m} \times 1.8\text{m}) \]

\[ L_2 = 6\text{ft} \times (1.8\text{m}) \times D_2 \text{ Quadrupole loop} \]

Presence loop, Wired in series

Wired to separate detectors/channels

### Design Speed

<table>
<thead>
<tr>
<th>Design Speed (mph (km/hr))</th>
<th>D1 (ft (m))</th>
<th>D2 (ft (m))</th>
<th>Gap Time (sec)</th>
<th>L1 Extend (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>250 (75)</td>
<td>40 (12)</td>
<td>2.0</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>60 (18)</td>
<td>1.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>300 (90)</td>
<td>40 (12)</td>
<td>2.0</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>60 (18)</td>
<td>1.0</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>355 (110)</td>
<td>40 (12)</td>
<td>2.0</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>60 (18)</td>
<td>1.0</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>420 (130)</td>
<td>40 (12)</td>
<td>2.0</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td>60 (18)</td>
<td>1.0</td>
<td>3.9</td>
<td></td>
</tr>
</tbody>
</table>

### Design Considerations:

- Cross intersection AND
- High speed [\(>40 \text{ mph} \ (64 \text{ km/hr})\)] AND
- Good horizontal and vertical alignment

### Notes:

- Loops L1 should be programmed for "EXTENSION" but NOT "CALLING."
- For TS-1 controllers, round Extend time up to nearest 0.25 seconds.
- Loop placement may be varied due to design constraints such as bridges or poor pavement, or non-standard placement of existing loops. In such cases, recalculate Extend times for L1 (See Std. 4.1.1:3).
- For TS2 controllers, in addition to appropriate extend time, loops L1 must be programmed with 100 second delay (INHIBIT DELAY DURING GREEN = YES) to ensure that the loop acts to only extend the phase.
- Loops L1 can double as system detectors, if wired separately.
Typical Detector Layouts

L1 = 6ft X 40ft (1.8m X 12.0m) Quadrupole loop
L2 = 6ft X 6ft (1.8m X 1.8m) [Minimum] Presence loop
   Wired to separate detector/channel
L3 = 6ft X 30ft (1.8m X 9.0m) Quadrupole loop

Notes:
- Call delay appropriate for right turn loops unless right turn on red is prohibited.
- Suggestions for delay:
  - Exclusive right turn lane: 15 sec
  - Right turn lane shared with through or through/ left movement: 10 sec or greater
- Do not program full time delay.

Delete detection for yield condition

Loop Placement for Side Street Right Turns

4.1.6

North Carolina Department of Transportation

Traffic Engineering and Safety Systems Branch
Signals & Geometrics Section

5-05
Locate loop slightly behind leading edge of stop line.

Note:
Loop may be located in advance of stop line when stop line is greater than 15' (4.5m) from edge of intersecting roadway; or, when loop detects a permissive or protected/permissive left turn.
### Amount of Inductance, Loop Wire, Sealant and Sawcut for Inductive Loops

Calculate additional loop wire or sawcut for loop wire tail section by measuring length of tail section from loop to edge of pavement.

**OR**

**ENGLISH**

\[ L \text{ (ft)} = 6 + (N - 1) \times 12 \]

**METRIC**

\[ L \text{ (m)} = 1.8 + (N - 1) \times 3.6 \]

Where: 
- \( L \) = Length of loop wire or sawcut
- \( N \) = Number of lanes crossed by tail section

To calculate additional sealant for loop wire tail section:

**ENGLISH**

\[ S \text{ (gal)} = \frac{L \text{ (ft)}}{33} \]

**METRIC**

\[ S \text{ (liters)} = \frac{L \text{ (m)}}{2.6} \]

Where: 
- \( S \) = Amount of sealant
- \( L \) = Length of sawcut required for tail section

*Amount of sealant is rounded up to nearest tenth of a gallon or liter*

---

**Loop Wire and Lead-In Calculations**

**SIGNS & GEOMETRICS SECTION**
**TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH**
**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**
Loop Inductance Notes

- Loop inductance should be equal to or greater than the lead-in inductance. A 2-to-1 ratio is preferable.

- Average lead-in cable inductance is .22µh/ft (.72µh/m)

- The minimum total inductance on a single digital detector (channel) is 50 µh, the maximum is 1000 µh.

- The maximum number of turns is 6.

- If the loop (excluding quadrupoles) will have more than 2" (50mm) of cover, add 1 turn to the loop over the normal calculated number of turns.

- Loops connected in series

  \[ L_{\text{Total}} = L_1 + L_2 + \ldots + L_N \]

  Where: \( N \) = Number of loops in series
  \( L \) = Loop inductance (µh)

- Recommended number of turns for a single 6' X 6' (1.8m X 1.8m) loop:

<table>
<thead>
<tr>
<th>Length of Lead-in ft (m)</th>
<th>Number of Turns</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 250 (75)</td>
<td>3</td>
</tr>
<tr>
<td>250-375 (75-115)</td>
<td>4</td>
</tr>
<tr>
<td>375-525 (115-160)</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 525 (160)</td>
<td>6</td>
</tr>
</tbody>
</table>

Loop Wire and Lead-In Calculations

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

5-05
Microwave Vehicle Detector

Design Consideration:
- Loops are not feasible due to bridges, poor pavement or anywhere loop lead-in can not be reasonably maintained such as constructions zones, etc.
- Typically used for only one to two detection areas, or one approach of an intersection.

Notes:
- Requires one microwave detector unit per detection zone.
- Microwave detector needs to face traffic.
- Some microwave detectors have specific detection zone size parameters based on mounting height and distance from zone.
- Cannot be used for system detection or vehicle counting.

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (FT)</th>
<th>TURN</th>
<th>DISTANCE FROM STOPBAR (FT)</th>
<th>NEW LOOP</th>
<th>NEW PHASE</th>
<th>NEW CALL</th>
<th>NEW DELAY</th>
<th>NEW TIME</th>
<th>NEW SYSTEM</th>
<th>NEW TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>*</td>
<td>*</td>
<td>70</td>
<td>Y</td>
<td>2</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Microwave Detection Zone*
Design Consideration:

- Loops are not feasible due to bridges, poor pavement, or anywhere loop lead-in can not be reasonably maintained such as constructions zones, etc.
- Flexibility is desired in detection areas due to traffic shifts associated with construction phasing.
- All other detection options have been exhausted.

Notes:

- Cannot be used for vehicle counting.
- Cannot be used for system detection.

### 2070L LOOP & DETECTOR INSTALLATION

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (FT)</th>
<th>TURNS</th>
<th>DISTANCE FROM STOPBAR (FT)</th>
<th>NEW LOOP</th>
<th>PHASE</th>
<th>COLLING</th>
<th>DURATION</th>
<th>DELAY TIME</th>
<th>LOOP</th>
<th>STRETCH TIME</th>
<th>DELAY TIME</th>
<th>NEW CAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>6X6</td>
<td>*</td>
<td>70</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
<td>*</td>
<td>0</td>
<td>5</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

*Video Detection Zone
<table>
<thead>
<tr>
<th>NOTES</th>
<th>WHEN TO USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L 04</td>
<td>Do not program signal for late night flashing operation unless otherwise directed by the Engineer.</td>
</tr>
<tr>
<td>L 05</td>
<td>This location contains railroad preemption phasing. Do not program signal for late night flashing operation.</td>
</tr>
<tr>
<td>L 10</td>
<td>Omit phase 1 during phase 2 on.</td>
</tr>
<tr>
<td>L 11</td>
<td>Program phase 1 as protected/permissive.</td>
</tr>
<tr>
<td>L 12</td>
<td>Omit phase 5 during phase 6 on.</td>
</tr>
<tr>
<td>L 13</td>
<td>Program phase 5 as protected/permissive.</td>
</tr>
<tr>
<td>L 14</td>
<td>Omit phase 3 during phase 4 on.</td>
</tr>
<tr>
<td>L 15</td>
<td>Program phase 3 as protected/permissive.</td>
</tr>
<tr>
<td>L 16</td>
<td>Omit phase 7 during phase 8 on.</td>
</tr>
<tr>
<td>L 17</td>
<td>Program phase 7 as protected/permissive.</td>
</tr>
<tr>
<td>L 18</td>
<td>Wire cabinet to allow the controller to clear from phase # to phase # by progressing through phase # (see Electrical Details for wiring).</td>
</tr>
<tr>
<td>L 19</td>
<td>Program controller to clear from phase # to phase # by progressing through phase # (see Electrical Details).</td>
</tr>
<tr>
<td>L 20</td>
<td>Enable Backup Protect for phase # to allow the controller to clear from phase # to phase # by progressing through an all red display.</td>
</tr>
<tr>
<td>L 21</td>
<td>Disable Backup Protect for phase #.</td>
</tr>
<tr>
<td>H 01</td>
<td>All Plans except Developer Plans</td>
</tr>
<tr>
<td>H 03</td>
<td>Developer Plans</td>
</tr>
<tr>
<td>H 04</td>
<td>For locations without railroad preemption</td>
</tr>
<tr>
<td>H 05</td>
<td>For locations with railroad preemption</td>
</tr>
<tr>
<td>H 10</td>
<td>Phase omit note for TS1, TS2, and 2070 operation</td>
</tr>
<tr>
<td>H 11</td>
<td>Phase omit note for 170 operation</td>
</tr>
<tr>
<td>H 12</td>
<td>Phase omit note for TS1, TS2, and 2070 operation</td>
</tr>
<tr>
<td>H 13</td>
<td>Phase omit note for 170 operation</td>
</tr>
<tr>
<td>H 14</td>
<td>Phase omit note for TS1, TS2, and 2070 operation</td>
</tr>
<tr>
<td>H 15</td>
<td>Phase omit note for 170 operation</td>
</tr>
<tr>
<td>H 16</td>
<td>Phase omit note for TS1, TS2, and 2070 operation</td>
</tr>
<tr>
<td>H 17</td>
<td>Phase omit note for 170 operation</td>
</tr>
<tr>
<td>H 18</td>
<td>Additional note for omit situations for TS1 operation</td>
</tr>
<tr>
<td>H 19</td>
<td>Additional note for omit situations for TS2, 2070, and 170 operation</td>
</tr>
<tr>
<td>H 20</td>
<td>Alternate to Phase Omits in 2070s. Used with Red Revert.</td>
</tr>
<tr>
<td>H 21</td>
<td>Use for FYA plans with existing 2070 cabinets where backup protection is no longer needed.</td>
</tr>
</tbody>
</table>
### NOTES

| L 22 | Phase 1 and/or phase 5 may be lagged. |
| L 23 | Phase 3 and/or phase 7 may be lagged. |
| L 24 | The order of phase 3 and phase 4 may be reversed. |
| L 25 | Program phase 4 and phase 8 for dual entry. |
| L 30 | Relocate existing signal heads numbered #. |
| L 31 | Reposition existing signal heads numbered #. |
| L 32 | Install backplates for signal heads numbered #. |
| L 33 | Tether signal heads numbered #. |
| L 40 | Run all lead-in cable overhead on existing utility poles where possible. |
| L 41 | Abandon existing loops #. |
| L 42 | Use controller input delay for phase #. Override channel # call delay during peak hours. |
| L 43 | Set all detector units to presence mode. |
| L 44 | In the event of loop replacement, refer to the current ITS and Signals Design Manual and submit a Plan of Record to the Signal Design Section. |
| L 50 | Locate new cabinet so as not to obstruct sight distance of vehicles turning right on red. |
| L 51 | The cabinet should be designed to include an Auxiliary Output File for future use. |
| L 52 | Program all timing information into phase banks 1, 2, and 3 unless otherwise noted. |
| L 53 | Set phase bank 3 maximum limit to 250 seconds for phases used. |
| L 60 | Omit "WALK" and flashing "DON'T WALK" with no pedestrian calls. |

### WHEN TO USE

<p>| H 21 | Use for exclusive left turns and Flashing Yellow Arrows |
| H 22 | Use for exclusive left turns and Flashing Yellow Arrows |
| H 23 | Use for split side streets |
| H 24 | For use with TS-1 or TS-2 equipment |
| H 30 | Use when head is moved to new span |
| H 31 | Use when head is &quot;slid&quot; on same span |
| H 32 | As needed |
| H 33 | As needed |
| H 40 | Urban projects with many driveways |
| H 41 | As needed, usually by contracts |
| H 42 | Add this note for variation on protected-permissive design. |
| H 43 | All Plans |
| H 44 | Use when not replacing “old style” loops |
| H 50 | All plans with new cabinets |
| H 51 | Use on plans with new 2070 cabinets and no FYA |
| H 52 | Standard with 170 operation |
| H 52 | Signal system plans with 170s |
| H 60 | Use for pedestrian-activated signals |</p>
<table>
<thead>
<tr>
<th>NOTES</th>
<th>WHEN TO USE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L 61</strong> Program pedestrian heads to countdown the flashing &quot;Don't Walk&quot; time only.</td>
<td><strong>H 61</strong> Use with countdown peds</td>
</tr>
<tr>
<td><strong>L 70</strong> Flash beacon # continuously.</td>
<td><strong>H 70</strong> Actuated flasher plan</td>
</tr>
<tr>
<td><strong>L 71</strong> Flash beacons # when actuated by loop #.</td>
<td><strong>H 71</strong> Actuated flasher plan</td>
</tr>
<tr>
<td><strong>L 80</strong> Thirty days after implementation of the revised signal operation, signs # and/or orange flags may be removed at the discretion of the Regional Traffic Engineer.</td>
<td><strong>H 80</strong> Use on plans being revised from fully protected or split side street phasing to protected-permissive phasing</td>
</tr>
<tr>
<td><strong>L 81</strong> Remove existing &quot;Left Turn Signal&quot; sign(s)-(R10-10L) and/or existing &quot;Right Turn Signal&quot; sign(s)-(R10-10R).</td>
<td><strong>H 81</strong> As needed</td>
</tr>
<tr>
<td><strong>L 82</strong> Existing &quot;Left Turn Yield on Green&quot; ball sign(s)-(R10-12) may be removed at the discretion of the Regional Traffic Engineer.</td>
<td><strong>H 82</strong> As needed</td>
</tr>
<tr>
<td><strong>L 90</strong> Pavement markings are existing.</td>
<td><strong>H 90</strong> Signal upgrades</td>
</tr>
<tr>
<td><strong>L 91</strong> Repaint stopbars and/or crosswalks.</td>
<td><strong>H 91</strong> As needed</td>
</tr>
<tr>
<td><strong>L 92</strong> Install pavement markings to designate lane separations for <strong>APPROACH</strong>.</td>
<td><strong>H 92</strong> As needed</td>
</tr>
<tr>
<td><strong>L 93</strong> Revise pavement markings as shown. All pavement markings and raised reflective markings shown are a representation of actual placement criteria. Refer to NCDOT Roadway Standard Drawings actual placement.</td>
<td><strong>H 93</strong> Safety plan with proposed reflectorized markings</td>
</tr>
<tr>
<td><strong>L 100</strong> Install box span, if possible.</td>
<td><strong>H 100</strong> As needed</td>
</tr>
<tr>
<td><strong>L 110</strong> This is a proposed plan view only. Field adjust all drainage, superelevation, utility conflicts, and grade changes.</td>
<td><strong>H 110</strong> Geometric changes only.</td>
</tr>
<tr>
<td><strong>L 120</strong> Locate emergency vehicle preemption switch in <strong>LOCATION</strong>.</td>
<td><strong>H 120</strong> Emergency vehicle preemption (pushbutton actuated)</td>
</tr>
<tr>
<td><strong>L 121</strong> The Division Traffic Engineer will determine the Delay Time and Preempt Dwell Min Time for the emergency vehicle preemption timing.</td>
<td><strong>H 121</strong> Emergency vehicle preemption (pushbutton actuated)</td>
</tr>
<tr>
<td><strong>L 122</strong> This intersection features an optical preemption system. Shown locations of optical detectors are conceptual only.</td>
<td><strong>H 122</strong> Optical preemption</td>
</tr>
<tr>
<td>NOTES</td>
<td>WHEN TO USE</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>L 123</strong> Program signal heads numbered # to clear to all red before going into preempt.</td>
<td><strong>H 123</strong> Use in place of dummy phase for emergency vehicle preemption</td>
</tr>
<tr>
<td><strong>L 124</strong> Ensure flashing operation does not alter operation of blankout signs.</td>
<td><strong>H 124</strong> Standard with RR preemption with blank-out signs</td>
</tr>
<tr>
<td><strong>L 125</strong> Clear signal heads numbered # from flashing 8” yellow to steady 12” yellow during interval 1 and steady red during interval 2.</td>
<td><strong>H 125</strong> RR preemption plans with advance flashing heads (for non-standard clearance)</td>
</tr>
<tr>
<td><strong>L 126</strong> Program start vehicle call OFF for phase #.</td>
<td><strong>H 126</strong> RR preemption plans with preempt phase that does not have corresponding regular phase (170 controller)</td>
</tr>
<tr>
<td><strong>L 127</strong> Program parent phases for Overlap “P” for all phases used in normal operation.</td>
<td><strong>H 127</strong> Most signal plans with railroad preemption that have a Track Clearance phase.</td>
</tr>
<tr>
<td><strong>L 128</strong> Upon completion of Railroad (or Emergency Vehicle) Preemption, controller returns to normal operation based on vehicle demand.</td>
<td><strong>H 128</strong> RR or EV Preemption plan when an exit phase (first normal phase served after preemption) is not or cannot be designated</td>
</tr>
<tr>
<td><strong>L 129</strong> The Division Traffic Engineer will determine the hours of use for each phasing plan.</td>
<td><strong>H 129</strong> Flashing Yellow Arrow plans designed with multiple or time of day phasing options.</td>
</tr>
<tr>
<td><strong>L 131</strong> These loops serve as queue backup detectors. After # seconds of constant actuation, the detector unit places a call to the controller to preempt normal operation to clear out the storage lanes.</td>
<td><strong>H 131</strong> Backup queue detectors</td>
</tr>
<tr>
<td><strong>L 132</strong> Existing Yellow Change Interval for phase # may be decreased by # seconds per week until the required value is reached.</td>
<td><strong>H 132</strong> Major adjustments to clearance times</td>
</tr>
<tr>
<td><strong>L 133</strong> Maximum times shown in timing chart are for free-run operation only. Coordinated signal system timing values supersede these values.</td>
<td><strong>H 133</strong> Standard with coordination</td>
</tr>
<tr>
<td><strong>L 134</strong> Closed loop system data: Intersection Number #, Local telemetry address number #, Channel number #.</td>
<td><strong>H 134</strong> Closed loop signal system plans</td>
</tr>
<tr>
<td><strong>L 135</strong> Closed loop system data: Master Asset #, Controller Asset #.</td>
<td><strong>H 135</strong> 2070 Closed loop signal system plans</td>
</tr>
</tbody>
</table>
# OASIS 2070L LOOP & DETECTOR INSTALLATION CHART

## INDUCTIVE LOOPS

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (FT)</th>
<th>DISTANCE FROM STOPBAR (FT)</th>
<th>TURNS</th>
<th>NEW LOOP</th>
<th>PHASE</th>
<th>CALLING</th>
<th>EXTENSION</th>
<th>FULL TIME DELAY</th>
<th>STRETCH TIME</th>
<th>DELAY TIME</th>
<th>SYSTEM LOOP</th>
<th>NEW CARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A/51</td>
<td>6X6</td>
<td>420</td>
<td>5</td>
<td>Y</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2B/52</td>
<td>6X6</td>
<td>420</td>
<td>5</td>
<td>Y</td>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>3A</td>
<td>6X15</td>
<td>50</td>
<td>3</td>
<td>Y</td>
<td>3</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>8A</td>
<td>6X40</td>
<td>+5</td>
<td>2-4-2</td>
<td>Y</td>
<td>8</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>4A</td>
<td>6X6</td>
<td>300</td>
<td>5</td>
<td>Y</td>
<td>4</td>
<td>-</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>4B</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>Y</td>
<td>4</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>2.0</td>
<td>5</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>5A</td>
<td>6X60</td>
<td>0</td>
<td>2-4-2</td>
<td>Y</td>
<td>5</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>6A, 6B</td>
<td>6X6</td>
<td>300</td>
<td>EXISTING</td>
<td>-</td>
<td>6</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>1.6</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>6C, 6D</td>
<td>6X6</td>
<td>90</td>
<td>EXISTING</td>
<td>-</td>
<td>6</td>
<td>Y</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
</tr>
<tr>
<td>S3</td>
<td>6X6</td>
<td>+120</td>
<td>4</td>
<td>Y</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

## Queue Detector

- Volume Density loops combined w/system loops
- Volume Density with D/EC for sidestreet
- Left turn loop calling 2 phases (with volume density on phase 2)

## Detector Programming Attributes

- **Calling** - Select to place call during red. Selecting this attribute is similar to selecting ALL for NEMA's "Place Call During Phase." (Usually selected)
- **Extension** - Select to extend the green time. Gap resets after each call. Must be selected whenever Vehicle Extension Time is entered in the timing chart. (Usually selected)
- **Full Time Delay** - Select to delay during red, yellow, and green. If not selected, controller will time delay during red and yellow only. Selecting this attribute is equivalent to selecting NO for NEMA's "Inhibit Delay During Green." (Usually not selected)
- **Stretch Time** - Enter times in intervals of .1 second

## Loop Chart Typicals

**Oasis 2070L Controller**

**Signal Design Section**

**Transportation Mobility and Safety Division**

**North Carolina Department of Transportation**

**Sheet 1 of 5**
### SE-PAC 2070 LOOP & DETECTOR UNIT INSTALLATION CHART

#### DETECTOR PROGRAMMING

<table>
<thead>
<tr>
<th>LOOP NO.</th>
<th>SIZE (ft)</th>
<th>TURNS</th>
<th>DIST. FROM STOPBAR (ft)</th>
<th>NEW</th>
<th>EXISTING</th>
<th>DELAY</th>
<th>EXTEND (STRETCH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A, 2B</td>
<td>6X6</td>
<td>5</td>
<td>300</td>
<td>X</td>
<td>-</td>
<td>2</td>
<td>- Sec. - Sec. X</td>
</tr>
<tr>
<td>3A, 3B</td>
<td>6X6</td>
<td>5</td>
<td>300</td>
<td>X</td>
<td>-</td>
<td>2</td>
<td>- Sec. - Sec. X</td>
</tr>
<tr>
<td>4A</td>
<td>6X6</td>
<td>5</td>
<td>300</td>
<td>X</td>
<td>-</td>
<td>4</td>
<td>100 Sec. - Sec. X</td>
</tr>
<tr>
<td>4B</td>
<td>6X40</td>
<td>2-4-2</td>
<td>0</td>
<td>X</td>
<td>-</td>
<td>4</td>
<td>5 Sec. 2.0 Sec. X</td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
<td>2-4-2</td>
<td>0</td>
<td>X</td>
<td>-</td>
<td>5</td>
<td>15 Sec. - Sec. X</td>
</tr>
<tr>
<td>5B</td>
<td>6X40</td>
<td>2-4-2</td>
<td>0</td>
<td>X</td>
<td>-</td>
<td>2</td>
<td>- Sec. - Sec. X</td>
</tr>
</tbody>
</table>

#### Detector Programming Attributes

- **Vehicle**: Vehicle detector operates as standard vehicle detector
- **Prot/Per Through**: Typically Not Used
- **Pedestrian**: Vehicle detector operates as standard pedestrian detector (Not Used)
- **And**: Typically Not Used
- **1 Call**: Typically Not Used
- **Stop A**: Typically Not Used
- **Stop B**: Typically Not Used
- **Prot/Per Left**: Typically Not Used

#### Loop ChartTypicals

**8-12**

**SIGNAL DESIGN SECTION**

**TRANSPORTATION MOBILITY AND SAFETY DIVISION**

**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**

**STD. NO.**

**5.1**

**SHEET 2 OF 5**
**NAZTEC 2070: Use with Greensboro Signal System**

### LOOP & DETECTOR UNIT INSTALLATION CHART

**NAZTEC APOGEE SOFTWARE 2070 CONTROLLER**

<table>
<thead>
<tr>
<th>INDUCTIVE LOOPS</th>
<th>DETECTOR PROGRAMMING</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOOP</td>
<td>SIZE (FT)</td>
</tr>
<tr>
<td>PP Left turn loop calling 2 phases</td>
<td>1A</td>
</tr>
<tr>
<td>VD loop combined w/system loop</td>
<td>2A/51</td>
</tr>
<tr>
<td>Stretch Detection for sidestreet</td>
<td>2B/52</td>
</tr>
<tr>
<td>PP Left turn loop calling 2 phases</td>
<td>4A</td>
</tr>
<tr>
<td>Stretch loops</td>
<td>4B</td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
</tr>
<tr>
<td>6A, 6B</td>
<td>6X6</td>
</tr>
<tr>
<td>6C, 6D</td>
<td>6X6</td>
</tr>
<tr>
<td>Protected left turn phase loop</td>
<td>7A</td>
</tr>
<tr>
<td>Sidestreet loop</td>
<td>8A</td>
</tr>
<tr>
<td>System Loop</td>
<td>S3</td>
</tr>
</tbody>
</table>

#### Detector Programming Attributes

- **Switch (Phase)** - Typically used for protected/_permitted left turns to call and extend the (primary) protected phase after the side street is serviced and extend the (secondary) permitted time for the corresponding adjacent through phase.

- **Calling** - Select to place call during red. Selecting this attribute is similar to selecting ALL for NEMA's "Place Call During Phase." (Usually selected)

- **Extension** - Select to extend the green time. Gap resets after each call. Must be selected whenever Vehicle Extension Time is entered in the timing chart. (Usually selected)

- **Added Init.** - Volume-density feature that extends the Minimum Green timer. Use if loop operates using volume-density detection

- **Stretch Time** - Enter in intervals of .1 second

**2070 Controller w/Naztec Apogee Software**

---

**Loop Chart Typical**

**SIGNAL DESIGN SECTION**

**TRANSPORTATION MOBILITY AND SAFETY DIVISION**

**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**

**STD. NO.**

**5.1**

**SHEET 3 OF 5**
# NEMA Loop & Detector Installation Chart

## with TS-1 Cabinet

### Inductive Loops

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (ft)</th>
<th>DIST. FROM STOPBAR (ft)</th>
<th>TURNS</th>
<th>NEW EXISTING</th>
<th>NEMA PHASE</th>
<th>TIMING PLACE CALL DURING PHASE</th>
<th>INHIBIT DELAY DURING GREEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>1</td>
<td>1 2</td>
<td>ALL NO</td>
</tr>
<tr>
<td>4A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>2</td>
<td>1 4</td>
<td>4 NO</td>
</tr>
<tr>
<td>4B</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>2</td>
<td>4 DCEC 52</td>
<td>ALL NO</td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>3</td>
<td>5 DELAY 15</td>
<td>ALL YES</td>
</tr>
<tr>
<td>6A, 6B</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>4</td>
<td>6 EXTEND 1.75</td>
<td>ALL NO</td>
</tr>
<tr>
<td>6C, 6D</td>
<td>6X6</td>
<td>90</td>
<td>4</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8A</td>
<td>6X40</td>
<td>0</td>
<td>EXIST</td>
<td>X</td>
<td>1</td>
<td>2 8</td>
<td>ALL NO</td>
</tr>
<tr>
<td>5D1</td>
<td>6X6</td>
<td>+150</td>
<td>4</td>
<td>X</td>
<td>5</td>
<td>2 System Detector</td>
<td></td>
</tr>
</tbody>
</table>

**Volume density loop**

**Volume Density with DCEC for sidestreet**

**Left turn loop calling 2 phases (with volume density on phase 2)**

**Stretch Loops**

**Sidestreet loop**

**System Loop**

Both of these charts are also used for Cary Signal System (2070N Equipment)

### NEMA Loop & Detector Installation Chart

## with TS-2 Cabinet

### Inductive Loops

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (ft)</th>
<th>DIST. FROM STOPBAR (ft)</th>
<th>TURNS</th>
<th>NEW EXISTING</th>
<th>NEMA PHASE</th>
<th>TIMING</th>
<th>INHIBIT DELAY DURING GREEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>2</td>
<td>-</td>
<td>NO</td>
</tr>
<tr>
<td>4A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>4</td>
<td>DELAY 100</td>
<td>YES</td>
</tr>
<tr>
<td>4B</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>4</td>
<td>DCEC 52</td>
<td>NO</td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>5</td>
<td>DELAY 15</td>
<td>YES</td>
</tr>
<tr>
<td>6A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>6</td>
<td>EXTEND 1.6</td>
<td>NO</td>
</tr>
<tr>
<td>6B</td>
<td>6X6</td>
<td>90</td>
<td>4</td>
<td>X</td>
<td>6</td>
<td>-</td>
<td>NO</td>
</tr>
<tr>
<td>8A</td>
<td>6X40</td>
<td>0</td>
<td>EXIST</td>
<td>X</td>
<td>8</td>
<td>-</td>
<td>NO</td>
</tr>
<tr>
<td>5D2</td>
<td>6X6</td>
<td>+150</td>
<td>4</td>
<td>X</td>
<td>-</td>
<td>System Detector</td>
<td></td>
</tr>
</tbody>
</table>

**Volume density loop combined w/ System Loop**

**Volume Density with DCEC for sidestreet**

**Left turn loop calling 2 phases (with volume density on phase 2)**

**Stretch loops**

**Sidestreet loop**

**System Loop**

Enter Stretch times in intervals of .25 second for TS-1 Cabinet

Enter Stretch times in intervals of .1 second for TS-2 Cabinet

---

# Loop Chart Typicalss

**Signal Design Section**

**Transportation Mobility and Safety Division**

**North Carolina Department of Transportation**

7-09
### 170 LOOP & DETECTOR INSTALLATION CHART

#### INDUCTIVE LOOPS

<table>
<thead>
<tr>
<th>LOOP</th>
<th>SIZE (ft)</th>
<th>DIST. FROM STOPBAR (ft)</th>
<th>TURNS</th>
<th>PHASE</th>
<th>DELAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>4A</td>
<td>6X6</td>
<td>EXIST</td>
<td>X</td>
<td>4</td>
<td>SEC.</td>
</tr>
<tr>
<td>4B</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>4</td>
</tr>
<tr>
<td>5A</td>
<td>6X40</td>
<td>0</td>
<td>2-4-2</td>
<td>X</td>
<td>5</td>
</tr>
<tr>
<td>6A, 6B</td>
<td>6X6</td>
<td>300</td>
<td>4</td>
<td>X</td>
<td>6</td>
</tr>
<tr>
<td>6C, 6D</td>
<td>6X6</td>
<td>90</td>
<td>4</td>
<td>X</td>
<td>6</td>
</tr>
<tr>
<td>8A</td>
<td>6X40</td>
<td>EXIST</td>
<td>X</td>
<td>8</td>
<td>SEC.</td>
</tr>
<tr>
<td>PB1, PB2</td>
<td>NA</td>
<td>NA</td>
<td>X</td>
<td>8</td>
<td>SEC.</td>
</tr>
</tbody>
</table>

#### DETECTOR PROGRAMMING

<table>
<thead>
<tr>
<th>Detector</th>
<th>TIMING</th>
<th>ATTRIBUTES</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Time Delay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carry (Stretch)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2A</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>4A</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>4B</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>5A</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>6A, 6B</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>6C, 6D</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>8A</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
<tr>
<td>PB1, PB2</td>
<td></td>
<td>- SEC.</td>
<td>X</td>
</tr>
</tbody>
</table>

### Detector Programming Attributes

- **Full Time Delay** - Select to delay during green and red. If not selected, controller will time delay during red only. Selecting this attribute is equivalent to selecting NO for NEMA's "Inhibit Delay During Green." (Usually not selected)
- **Pedestrian Call** - Select to assign as a pedestrian detector. Used with ped push-button.
- **Reserved** - Currently not in use. (Not selected)
- **Count** - Select to count vehicles. (Usually selected with volume density loops)
- **Extension** - This allows the detector to extend the green time. Gap resets after each call. Must be selected whenever Vehicle Extension Time is entered in the timing chart. (Usually selected)
- **Type 3** - This attribute will place call during green until the call drops or the Type 3 Limit expires. Once the Type 3 detector drops off it will not be active until the next phase. This attribute is similar to NEMA's EC/DC operation except that the loop is disconnected after a set time instead of after a gap in traffic. (Usually not selected)
- **Calling** - Select to place call during red. Selecting this attribute is similar to selecting ALL for NEMA's "Place Call During Phase." (Usually selected)
- **Carry (Stretch)** - Enter times in intervals of .1 second

### Loop Chart Typicals

**Transportation Mobility and Safety Division**

**North Carolina Department of Transportation**

**Signal Design Section**

**5.1**

**Sheet 5 of 5**
For All Plans

**Oasis 2070L Timing Chart (Part 1)**

- **Main Street:**
  55 mph (88 km/hr) - 14 sec
  50 mph (80 km/hr) - 14 sec
  45 mph (72 km/hr) - 12 sec
  40 mph (64 km/hr) - 12 sec
  ≤35 mph (56 km/hr) - 10 sec

  Side Streets, Lefts, and Main Street Stopbar Detection:
  Set to 4-8 sec, depending on size of detection area, grade, truck traffic, etc.
  Typically 7 sec.

- **Main Street - Typically 2.0 sec for stretch detection, 3.0 sec for low speed detection.** For volume density, amount of time required to get vehicle traveling 5 mph (8 kph) under the speed limit from upstream loop to stop line, generally 6.0 sec.

- **Side Street - Typically 1.0-3.0 sec.** Adjust for size of detection area, grade, truck traffic, etc.

- **Maximum green times may be determined with the help of a software package.** Alternately, a hand calculation may be suitable:

  \[ \text{Max Green} = 4 + 2 \left( \frac{\text{Heaviest PHV per lane}}{3800/\text{est cycle length}} \right) \]

  \[ \text{PHV} = \text{Peak hour volume} \]

- **See STD. NO. 5.2.2**

- **A type of Backup Protection.** Typically set to 5.0 for phase(s) used, otherwise default is 2.0 sec. (See Std. 2.3)

  Typically 4-7 seconds

- **See STD. NO. 6.0**

- **None, Min Recall, Max Recall, Soft Recall, Ped Recall or Ped Soft Recall**

- **None, Red, or Yellow (See Definitions)**

- **On or not selected (see Definitions)**

- **On or not selected, usually selected (see Definitions)**

  Note: For Pre-Timed Signal, set Extension 1 to 0.0 and Recall Position to Max Recall. Enter N/A for Vehicle Call Memory.

---

**OASIS 2070L TIMING CHART**

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Min Green 1*</td>
<td>10</td>
</tr>
<tr>
<td>Extension 1*</td>
<td>3.0</td>
</tr>
<tr>
<td>Max Green 1*</td>
<td>45</td>
</tr>
<tr>
<td>Yellow Clearance</td>
<td>3.6</td>
</tr>
<tr>
<td>Red Clearance</td>
<td>1.9</td>
</tr>
<tr>
<td>Red Revert</td>
<td>5.0</td>
</tr>
<tr>
<td>Walk 1*</td>
<td>4</td>
</tr>
<tr>
<td>Don't Walk 1</td>
<td>12</td>
</tr>
<tr>
<td>Seconds Per Actuation*</td>
<td>-</td>
</tr>
<tr>
<td>Max Variable Initial*</td>
<td>-</td>
</tr>
<tr>
<td>Time Before Reduction*</td>
<td>-</td>
</tr>
<tr>
<td>Time To Reduce*</td>
<td>-</td>
</tr>
<tr>
<td>Minimum Gap</td>
<td>-</td>
</tr>
<tr>
<td>Recall Mode</td>
<td>MIN RECALL</td>
</tr>
<tr>
<td>Vehicle Call Memory</td>
<td>YELLOW</td>
</tr>
<tr>
<td>Dual Entry</td>
<td>-</td>
</tr>
<tr>
<td>Simultaneous Gap</td>
<td>ON</td>
</tr>
</tbody>
</table>

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

---

**Signal Plan Timing Chart**

*Signal Design Section*

*Transportation Mobility and Safety Division*

*North Carolina Department of Transportation*
Oasis 2070L Timing Chart (Part 2)

For Volume Density Plans (See 5.2.3 Sheet 1)

Variable Initial Features (Time only during non-green portion of phase)

- Amount added to Variable Initial Time (starting at 0) for each actuation of detector loops. Typical values:
  - 2.5 secs for single through lane
  - 1.5-1.8 sec for two through lanes
  - 1.0-1.5 sec for three through lanes
When traffic is more evenly distributed over multiple lanes, use lower number. Increase for high truck traffic.

- Time needed to service a queue reaching from detector loop to stop line. Calculated by:
  
  Maximum Variable Initial = 4 + 2 \left( \frac{\text{Distance to loop}}{\text{Std veh length = 20'}} \right)

Gap Reduction Features (Time only during green portion of phase)

- Time that expires before gap reduction begins. Prevents premature transfer of green. Typically 15-30 secs, but never less than the minimum green.
  For sidestreet Volume Density, may use 0 or 5 sec.

- Amount of time over which gap time will reduce from initial value (Extension 1) to minimum value (Minimum Gap). Typically 30-60 secs.
  For sidestreet Volume Density, may use 15 or 20 sec.

- Set equal to lowest gap time that allows vehicle to clear dilemma zone. Typically 3.0 sec - 4.0 sec., but no lower than 3.4 sec. for 55 MPH

Notes:
- The sum of the Time Before Reduction and the Time to Reduce should not exceed the Max Green 1 time.
- The Extension 1 resets to the initial value if the serviceable conflicting call is removed (eg. Turns right on red).
SE-PAC 2070 Timing Chart
(Burlington, Hickory and Raleigh Signal Systems)

For All Plans
- See Sheet 1, Min Green 1
- See Sheet 1, Extension 1
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- See Sheet 1, Walk 1
- See Sheet 1, Don’t Walk 1

For Volume Density Plans
- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans
- None, Min Recall, Max Recall, Soft Recall, or Ped Recall
- Lock or Non-Lock (See Definitions)
- On or not selected (see Definitions)
- On or not selected, usually selected (see Definitions)

Note: For Pre-Timed Signal, set Extension 1 to 0.0 and Recall Position to Max Recall. Enter Non-Lock for Vehicle Call Memory.

Note: SE-PAC Software cannot use Red Revert for backup protection. Phase omits must be used.

SE-PAC 2070 TIMING CHART

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>2</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Green *</td>
<td>10</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Passage Gap *</td>
<td>3.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Maximum Green *</td>
<td>45</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>Yellow Change</td>
<td>3.9</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Red Clear</td>
<td>1.8</td>
<td>2.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Walk *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedestrian Clear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added Initial *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum Initial *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Before Reduction *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time To Reduce *</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Gap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall Mode</td>
<td>MIN RECALL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Call Memory</td>
<td>LOCK</td>
<td>NON-LOCK</td>
<td></td>
</tr>
<tr>
<td>Dual Entry</td>
<td></td>
<td>ON</td>
<td></td>
</tr>
<tr>
<td>Simultaneous Gap</td>
<td>ON</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.
Naztec Apogee 2070 Timing Chart  
(Greensboro Signal System)

For All Plans
- See Sheet 1, Min Green 1
- See Sheet 1, Extension 1
- See Sheet 1, Max Green 1
- See STD. NO. 5.2.2
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1

For Volume Density Plans
- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial
- See Sheet 2, Time Before Reduction
- See Sheet 2, Time to Reduce
- See Sheet 2, Minimum Gap

For All Plans
- None, Min Recall, Max Recall, Soft Recall, or Ped Recall
- Yes or No (See Definitions)
- On or not selected (see Definitions)
- On or not selected, usually selected (see Definitions)

Note: For Pre-Timed Signal, set Gap, Extension 1 to 0.0 and Recall Position to Max Recall. Enter No for Lock Calls.

Note: Naztec Apogee Software can not use Red Revert for backup protection. Phase omits must be used.

---

NAZTEC APOGEE 2070 TIMING CHART

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Green *</td>
<td>12 7 7</td>
</tr>
<tr>
<td>Gap, Extension *</td>
<td>6.0 2.0 2.0</td>
</tr>
<tr>
<td>Maximum Green 1 *</td>
<td>90 30 20</td>
</tr>
<tr>
<td>Maximum Green 2 *</td>
<td>110 25 25</td>
</tr>
<tr>
<td>Yellow Clear</td>
<td>5.1 3.8 3.0</td>
</tr>
<tr>
<td>Red Clear</td>
<td>1.2 1.9 2.1</td>
</tr>
<tr>
<td>Walk *</td>
<td>4 – –</td>
</tr>
<tr>
<td>Pedestrian Clear</td>
<td>16 – –</td>
</tr>
<tr>
<td>Added Initial *</td>
<td>1.5 –</td>
</tr>
<tr>
<td>Maximum Initial *</td>
<td>34 –</td>
</tr>
<tr>
<td>Time Before Reduction *</td>
<td>15 –</td>
</tr>
<tr>
<td>Time To Reduce *</td>
<td>60 –</td>
</tr>
<tr>
<td>Minimum Gap</td>
<td>3.0 –</td>
</tr>
<tr>
<td>Recall Mode</td>
<td>MIN RECALL –</td>
</tr>
<tr>
<td>Lock Calls</td>
<td>YES NO</td>
</tr>
<tr>
<td>Dual Entry</td>
<td>– ON</td>
</tr>
<tr>
<td>Simultaneous Gap</td>
<td>ON ON</td>
</tr>
</tbody>
</table>

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.
NEMA Timing Chart (Also for Cary 2070N Signal System)

For All Plans
- See Sheet 1, Min Green 1
- See Sheet 1, Extension 1
- See Sheet 1, Max Green 1
- None, Min Recall, Max Recall, Soft Recall or Ped Recall
- Lock or Nonlock
- See Sheet 1, Walk 1
- See Sheet 1, Don't Walk 1

For Volume Density Plans (See 5.2.3 Sheet 1)
Variable Initial Features (Active only during non-green portion of phase)
- Number of vehicles that arrive that will not count toward Maximum Initial value. For most controllers, this value is zero. If needed (such as Traconex TMP 390 and Minnesota Microtronics 800 controllers), the Actuation B4 Add may be calculated:
  \[ \text{Actuation B4 Add} = \frac{\text{Min Green} - 4}{2} \]
- Amount added to Variable Initial Time (starting at 0) for each actuation of detector loops. Typical values:
  - 2.5 secs for single through lane
  - 1.5-1.8 sec for two through lanes
  - 1.0-1.5 sec for three through lanes
- When traffic is more evenly distributed over multiple lanes, use lower number. Increase for high truck traffic.
- For the Traconex and Minnesota Microtronics controllers:
  - 2.0 secs for single through lane
  - 1.3-1.5 sec for two through lanes
  - 1.0-1.3 sec for three through lanes
- See Sheet 2, Maximum Variable Initial

Gap Reduction Features (see Sheet 2)
Notes:
- The sum of the Time Before Reduction and the Time to Reduce should not exceed the Max Green 1 time.
- The Passage/Gap resets to the initial value if the serviceable conflicting call is removed (eg. Turns right on red).

NEMA TIMING CHART

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Green*</td>
<td>12</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Passage/Gap*</td>
<td>6.0</td>
<td>1.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Yellow Change Int</td>
<td>4.3</td>
<td>3.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Red Clearance</td>
<td>1.4</td>
<td>2.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Maximum 1*</td>
<td>90</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Recall Position</td>
<td>MIN RECALL</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>Vehicle Call Memory</td>
<td>LOCK</td>
<td>NONLOCK</td>
<td></td>
</tr>
<tr>
<td>Walk*</td>
<td>4</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Flashing Don't Walk</td>
<td>12</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Volume Density</td>
<td>ON</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td>Actuation B4 Add*</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sec Per Actuation*</td>
<td>2.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Maximum Initial*</td>
<td>34</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Time B4 Reduction*</td>
<td>15</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Time To Reduce*</td>
<td>30</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Minimum Gap</td>
<td>3.0</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

Note: For Pre-Timed Signal, set Passage/Gap to 0.0 and Recall Position to Max Recall. Enter N/A for Vehicle Call Memory.

Note: NEMA Equipment cannot use Red Revert for backup protection. Phase omits must be used.
For All Plans

- See Sheet 1, Min Green 1
- See Sheet 1, Extension 1
- See STD. NO. 5.2.2
- See Sheet 1, Max Green 1
- None, Veh Recall, Ped Recall, Max Recall, Soft Recall
- None, Yellow Lock, Red Lock
  Yellow Lock begins locking call during yellow, Red Lock begins locking call during red. Typically None for stopbar detection and Yellow Lock for setback detection.
- On or Off
- See Sheet 1, Walk 1
- See Sheet 1, Don’t Walk 1
- Used with Type 3 Limit Detector Attribute, See STD NO. 5.2:3

For Volume Density Plans (See 5.2.3 Sheet 2)

Variable Initial Features (Active only during non-green portion of phase)
- See Sheet 2, Seconds per Actuation
- See Sheet 2, Maximum Variable Initial

Gap Reduction Features (Time only during green portion of phase)
- The gap the controller starts reducing from. Unlike NEMA and 2070L controllers, the 170 starts reducing this gap immediately. Typically 6.8-8.0 secs. If Volume Density is not used, enter Vehicle Extension time, as a time must be entered.
- Maximum Gap reduces by 0.1 sec after this much time until it reduces to the Minimum Gap. Typically 1.0-2.4 secs.
- See Sheet 2, Minimum Gap. If Volume Density is not used, enter Vehicle Extension time, as a time must be entered.

### 170 TIMING CHART

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Initial*</td>
<td>12</td>
</tr>
<tr>
<td>Vehicle Extension*</td>
<td>6.0</td>
</tr>
<tr>
<td>Yellow Change Int</td>
<td>4.3</td>
</tr>
<tr>
<td>Red Clearance</td>
<td>1.4</td>
</tr>
<tr>
<td>Maximum Limit*</td>
<td>90</td>
</tr>
<tr>
<td>Recall Position</td>
<td>VEH RECALL</td>
</tr>
<tr>
<td>Vehicle Call Memory</td>
<td>YELLOW LOCK</td>
</tr>
<tr>
<td>Double Entry</td>
<td>OFF</td>
</tr>
<tr>
<td>Walk*</td>
<td>4</td>
</tr>
<tr>
<td>Flashing Don’t Walk</td>
<td>12</td>
</tr>
<tr>
<td>Type 3 Limit</td>
<td>-</td>
</tr>
<tr>
<td>Add Per Vehicle*</td>
<td>1.5</td>
</tr>
<tr>
<td>Maximum Initial*</td>
<td>34</td>
</tr>
<tr>
<td>Maximum Gap*</td>
<td>7.0</td>
</tr>
<tr>
<td>Reduce 0.1 Sec Every*</td>
<td>1.5</td>
</tr>
<tr>
<td>Minimum Gap</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* These values may be field adjusted. Do not adjust Min Green and Extension times for phases 2 and 6 lower than what is shown. Min Green for all other phases should not be lower than 4 seconds.

**Notes:**
- For non-volume density operation, set Maximum Gap and Minimum Gap equal to Vehicle Extension.
- For Pre-Timed Signal, set Vehicle Extension to 0.0 and Recall Position to Max Recall. Enter none for Vehicle Call Memory.
Through Movement Clearance Distances

Round distances up to the nearest 5' (1m) increment unless distance is very long

Need to clear right turn (if signalized)

Yield Sign

When pedestrian signals are present, clear to the near side of the crosswalk
Standard Left Turn Movement Clearance Distances

Round distances up to the nearest 5' (1m) increment unless distance is very long.

When pedestrian signals are present, clear to the near side of the crosswalk.

Change and Clearance Intervals
Other Left Turn Movement Clearance Distances
Median, Dual Left, Setback

Round distance up to the nearest 5' (1m) increment unless distance is very long

Extend clearance line to clear median

Yield Sign

Change and Clearance Intervals

STANDARD NO. 5.2.2
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
**Determination of Yellow Change and Red Clearance Intervals**

### Yellow Change Interval

<table>
<thead>
<tr>
<th>Notes</th>
<th>Design speed is the speed limit unless a speed study determines that the 85th percentile speed is faster or intersection geometrics compel vehicles to traverse the intersection slower.</th>
</tr>
</thead>
<tbody>
<tr>
<td>t =</td>
<td>perception reaction time, typically 1.5 seconds</td>
</tr>
<tr>
<td>v =</td>
<td>design speed*, in ft/sec</td>
</tr>
<tr>
<td>a =</td>
<td>deceleration rate, typically 11.2 ft/sec²</td>
</tr>
<tr>
<td>g =</td>
<td>grade</td>
</tr>
</tbody>
</table>

Minimum yellow change interval is 3.0 seconds.

Hold stakeholder discussion** when calculated yellow change interval is longer than 6.0 seconds.

### Red Clearance Interval

<table>
<thead>
<tr>
<th>Notes</th>
<th>The purpose of a stakeholder discussion is to provide advance notification and involvement to stakeholders and provide an opportunity to consider possible countermeasures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>w =</td>
<td>width of intersection, in feet</td>
</tr>
<tr>
<td>v =</td>
<td>design speed*, in ft/sec</td>
</tr>
</tbody>
</table>

Red clearance interval should be between 1.0 and 6.0 sec.

Hold stakeholder discussion** when recalculated red clearance interval is longer than 4.0 seconds.

Sources:


<table>
<thead>
<tr>
<th>Change and Clearance Intervals</th>
<th>SIGNAL DESIGN SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STD. NO.</td>
<td>5.2.2</td>
</tr>
<tr>
<td>TRANSPORTATION MOBILITY AND SAFETY DIVISION</td>
<td></td>
</tr>
<tr>
<td>NORTH CAROLINA DEPARTMENT OF TRANSPORTATION</td>
<td></td>
</tr>
</tbody>
</table>
Variable Initial Parameters

Variable initial operation increases the MIN Green interval in a manner dependent upon the number of vehicle actuations placed on the phase while it is in the Yellow or Red interval. The variable initial interval is calculated as a function of the vehicle actuations and the MIN Green, Seconds Per Actuation, and MAX Variable Initial settings. The following relationship calculates the variable initial interval:

\[
\text{Initial Interval} = (\text{# of Vehicle Actuations}) \times (\text{Seconds Per Actuation Setting})
\]

If the calculated initial interval is less than the MIN Green setting, the MIN Green time will be used as the initial interval. If the calculated initial interval is greater than the MAX Variable initial setting, the MAX Variable initial will be used as the initial interval.

Gap Reduction Parameters

Gap Reduction reduces the allowable gap between successive vehicle actuations by dynamically decreasing the extension time. The rate of reduction is based on the setting of the Extension, Minimum Gap, and Time to Reduce settings. Using this method, the gap will be reduced by the following relationship:

\[
\text{Reduction} = \frac{\text{Extension} - \text{Minimum Gap} \times (\text{Current Green Interval Time} - \text{TBR})}{\text{TTR}}
\]

This reduction begins when the Green interval has timed the Time Before Reduction (TBR) setting. Reduction of the allowable gap will continue until the gap reaches a value equal to or less than the Minimum Gap. In the presence of continual vehicle actuations, the phase will not gap out, even if the gap has been reduced to zero.
Maximum Initial = 34 sec

Minimum Initial = 12 sec

\( v_0 = \) Beginning of phase red with no vehicles waiting

Add per Vehicle = 2.5 sec

Queue reaches detector loop

One vehicle arrival

Variable Initial Parameters

Maximum Gap = 7.0 sec

Vehicle Extension = 6.0 sec

Minimum Gap = 3.0 sec

Reduce 0.1 Sec Every 1.5 sec

0.1 sec (Step size)

Note: The controller begins timing the gap reduction from the Maximum Gap (7.0 sec) when it gets a conflicting call; however, the 'real' maximum gap is the Vehicle Extension (6.0 sec). The Vehicle Extension time will never go above 6.0 seconds. The time the controller takes to reach the Vehicle Extension from the Maximum Gap is the 170's version of Time B4 Reduction.

Gap Reduction Parameters

Volume Density Timing Example - 170 Controller
### Standard Signal Plan Legend

#### Legend

**Proposed**
- Traffic Signal Head
- Modified Signal Head
- Pedestrian Signal Head
- Sign
- Signal Pole with Guy
- Signal Pole with Sidewalk Guy
- Inductive Loop Detector
- Controller & Cabinet
- Junction Box
- 2-in Underground Conduit
- Right of Way
- Directional Arrow

**Existing**
- Modified Pedestrian Head
- Metal Strain Pole
- Metal Pole with Mastarm
- Signal Pedestal
- Directional Drill
- Out of Pavement Detector
- Video Detection Area
- Out of Pavement Detection Area
- Master Controller & Cabinet
- Railroad Cantilever
- Railroad Gate and Flasher
- Railroad Tracks
- Construction Zone Drums
- Construction Zone
- New Pavement
- Wheelchair Ramp
- Wheelchair Ramp
- Sign I.D.

**Proposed**
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A

**Existing**
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A
- N/A

### Note:

Symbols for utilities, hydrology, property lines, etc. should mirror standards set by NCDOT's Roadway Design Unit.

---

### Common Drawing Symbols

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-09
Typical Appearance of Signal Face I.D.

**SIGNAL FACE I.D.**

All Heads L.E.D.

12" (300mm)

51  11, 12  21, 22  42  61, 62

Signal Faces/Heads with Special Characteristics

- **Optically Programmed Head**
  - R Y G
  - 12" (300mm)

- **Section with Louver**
  - R Y (or similar)
  - 12" (300mm)

---

**Signal Face I.D. Details**

STANDARD AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-09

STD. NO. 5.4
Project Type
Indicate whether 'New Installation,' 'Signal Upgrade,' or 'Temporary Signal.'

Graphic Scale
Include a graphic scale on all plans.

Plan Description
Description should include:
# Phases
Type of Actuation
w/ Special Features (if any)
Isolated or System (including type)

Text and Lettering
-Letter sizes should approximate the following:
Title block street names and title heads...3/16in (5mm)
All other lettering..............................1/8in (3mm)

-List the routes in the title block using the word "at", not "and", as follows:
SR XXXX (Tree Avenue) at SR XXXX (Stump Drive)
-OR-
SR XXXX (Tree Avenue) at SR XXXX (Stump Drive)/NC 123 (Branch Street)

Metric Block
For metric plans, include the metric block in the upper righthand corner.

North Arrow
For Spot Safety projects, align the main street to run horizontally across the plan where possible. For Contract projects, align the plan in the same general direction as the roadway plans. For closed loop system projects, align signal plan sheets in the same general direction as the cable routing plans where possible.

Address
For plans developed in house, include the department logo with the Signals & Geometrics Section's address in the title block.

For plans developed by private engineering firms, include the department logo with the Signals & Geometrics Section's address in the title block and the firm's name with address on the plan sheet beside the title block.

For plans developed by municipalities, include the department logo with the Signals & Geometrics Section's address in the title block and the municipality's name with address on the plan sheet beside the title block.

For plans developed by private engineering firms for a municipality, include the department logo with the Signals & Geometrics Section's address in the title block and the firm's name with address on the plan sheet beside the title block.

Note: Private engineering firms and municipalities are responsible for placing their name with address on the plans. Company or municipal logos are permitted providing they do not detract from the plan.
Typical Signal Plan Layout

- Phasing Diagram with Detection Legend
- Table of Operation
- Loop Chart
- Signal Face I.D.
- Intersection
- Timing Chart
- Proposed Pavement Markings or Pole Locations (if required)

Miscellaneous Drawing Format Items

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.5
SHEET 2 OF 4
Revisions

When revising an existing traffic signal plan, include the revision number, date, and revision description. Additionally, enclose the revision number in a triangle and place the triangle on the plans near the affected area if needed for clarity.

When the PE making the revision is the same PE who sealed the original plan, the PE initials and dates the revision block and reseals the original plan with the original date.

**Signal Upgrade**

When the PE making the revision is different than the PE who sealed the original plan, then a "Revision Seal" block needs to be added to the title block to the left (preferred) or just above the title block on the original plans. In addition, add the text "Not a certified document as to the Original Document but only as to the Revisions - This document originally issued and sealed by 'name,' 'PE number,' on 'date.' This document is only certified as to the revisions."

**Miscellaneous Drawing Format Items**

**SIGNAL DESIGN SECTION**

**TRANSPORTATION MOBILITY AND SAFETY DIVISION**

**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**
Signal Cable Calculations

Signal Cable

There is only one pay item for signal cable; combine measurements for 16-4 and 16-7 cable. Route cable to minimize the length of cable used. Add 3' (1 m) extra in cabinets. Add 3' (1 m) extra at each signal head. Assume 30' (10 m) down poles. Note: Use 2 separate cable runs if there are more than 6 heads on a phase.

Example (See sheet 2)

Heads 61 & 62:
3' (beside head) + 12' + 3' (beside head) + 270' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 331'

Head 11
3' (beside head) + 256' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 302'

Heads 41 & 42:
3' (beside head) + 15' + 3' (beside head) + 105' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 169'

Head 43:
3' (beside head) + 220' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 266'

Heads 31, 32, 33 & 34:
3' (beside head) + 15' + 3' (beside head) + 10' + 3' (beside head) + 12' + 3' (beside head) + 150' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 242'

Heads 21 & 22:
3' (beside head) + 15' + 3' (beside head) + 55' + 30' (down pole) + 10' (to cabinet) + 3' (in cabinet) = 119'

Total: 331' + 302' + 169' + 266' + 242' + 119' = 1429'

Round up to nearest 10' = 1430'

Plan Quantity Calculations

SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.6

7-09 SHEET 1 OF 4
Messenger Cable & Loop Lead-In Calculations

Messenger Cable (Spanwire)

Example (See sheet 4)

Note: Do not add any length for guys as they are included as a pay item for guy assemblies.

\[145' + 170' + 110' + 172' = 597'\]

Round up to nearest 10' = 600'

Loop Lead-In Cable

Each loop lead-in wire connects 1 loop to the cabinet if the is wired separately. Quadrupole and volume density (counting) loops need to be wired separately. If multiple loops are wired together, 1 lead-in connects the group to the cabinet. Low speed and extend (stretch) loops may be wired together. Include lead-in for pedestrian pushbuttons and microwave detectors. Assume 30' (10 m) up or down poles.

Example (See sheet 4)

Loops 2A & 2B (together) and 5A (separate):
\[25' + 30' \text{ (up pole)} + 172' + 30' \text{ (down pole)} + 10' \text{ (to cabinet)}\]

\[= 267' \times 2 = 534'\]

Loop 6A and 6B (each separate):
\[250' + 25' + 30' \text{ (up pole)} + 110' + 30' \text{ (down pole)} + 10' \text{ (to cabinet)}\]

\[= 455' \times 2 = 910'\]

Loop 1A:
\[25' + 30' \text{ (up pole)} + 110' + 30' \text{ (down pole)} + 10' \text{ (to cabinet)}\]

\[= 205'\]

Loops 3A, 3B, and 3C (each separate): 15'

\[= 15' \times 3 = 45'\]

Loop 4A and 5B (each separate):
\[50' + 30' \text{ (up pole)} + 170' + 110' + 30' \text{ (down pole)} + 10' \text{ (to cabinet)}\]

\[= 400' \times 2 = 800'\]

Total: 534' + 910' + 205' + 45' + 800' = 2494'

Round up to nearest 10' = 2500'
Loop Lead-In & Messenger Cable Example Diagram

50' Separate 4A & 5B

25' Separate each loop

250' Separate 6A & 6B

Plan Quantity Calculations
SIGNAL DESIGN SECTION
TRANSPORTATION MOBILITY AND SAFETY DIVISION
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 5.6
SHEET 4 OF 4

7-09
Typical Pedestrian Heads

Pedestrian Head Guidelines
- With pretimed operation, use "Ped Recall" when push buttons are not used.
- Also with pretimed operation, "Max Time" should not be less than the total of "Walk" and "Flashing Don't Walk" times.
- Typically, do not use countdown pedestrian heads with railroad preemption (unless pretimed operation).
- Countdown heads may not be compatible with some forms of EV or Fire Preemption.
- Existing 9" (225 mm) Housing, 2 section pedestrian heads are allowed when distance to head is less than 100 feet (30m).
- For head numbering refer to Std. No. 3.0:1.

Pedestrian Timing
- "Walk Time": Minimum 4 to 7 seconds, depending on pedestrian volume and characteristics.
- "Flashing Don't Walk Time" (FDW): Enough time to get from curb or shoulder to far side of the farthest traveled lane (D). Assume 4 feet (1.2m) per second (S), minus the concurrent yellow change interval (YC). Use slower travel speed where a high percentage of slower moving pedestrian traffic can be expected.
  \[ FDW = \frac{D}{S} - YC \]
## Typical Numbering for Flashers

- **11**
- **12**
- **21**
- **22**
- **23**
- **24**
- **13**
- **14**

### (Main Street)

### Side Street

### SIGNAL FACE I.D.

- **21, 23**
  - **Y**
  - **R**
  - **11, 13**
  - **18”**
  - **(450mm)**
  - **min**

- **22, 24**
  - **Y**
  - **R**
  - **12, 14**

## Table of Operation for Flashers

<table>
<thead>
<tr>
<th>SIGNAL FACE</th>
<th>INTERVAL 1</th>
<th>INTERVAL 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>OFF</td>
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<tr>
<td>OFF</td>
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<tr>
<td>ON</td>
<td>OFF</td>
<td></td>
</tr>
<tr>
<td>OFF</td>
<td>ON</td>
<td></td>
</tr>
</tbody>
</table>

---

**Flashers**

**Signals & Geometrics Section**

**Traffic Engineering and Safety Systems Branch**

**North Carolina Department of Transportation**

**STD. NO.**

**7.0**

**Sheet 1 of 5**
Signal Head Approach Display and Alignment

Single Lane Approach

Single Lane Approach with Turning Bay

Multilane Approach

* Engineer to determine based on site specific characteristics

General Guidelines

- Flash vertically mounted heads alternatively
- Flash horizontally mounted heads concurrently

Flashers
Actuated Flasher with Overhead Sign

Single Lane Approach

Single Lane Approach with Turning Bay

Multilane Approaches

General Guidelines

- Sign may be installed at intersection or in advance of intersection, at engineer’s discretion
- Typical sign size: 114” x 36”
- Lettering size: 8” D
- See drawing notes (Std. No. 5.0) for notes specific to actuated flashers

Flashers

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

7-04

STD. NO.
7.0
SHEET 3 OF 5
Actuated Flasher with Ground-Mounted Sign

Single or Multi Lane Approaches

General Guidelines

- For multilane divided roadways with medians, dual ground mounted signs may be installed
- See drawing notes (Std. No. 5.0) for notes specific to actuated flashers
- Refer to MUTCD Table 2C-4 for advance placement of signs

Flashers

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 7.0

SHEET 4 OF 5
Loop Placement for Actuated Flashers

Main Street Loop Placement (Single or Multilane)

Side Street Loop Placement

<table>
<thead>
<tr>
<th>Design Speed mph (km/hr)</th>
<th>D in ft (m)</th>
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<tbody>
<tr>
<td>40 (64)</td>
<td>250 (75)</td>
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<tr>
<td>45 (72)</td>
<td>300 (90)</td>
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<tr>
<td>50 (80)</td>
<td>355 (110)</td>
</tr>
<tr>
<td>55 (88)</td>
<td>420 (130)</td>
</tr>
</tbody>
</table>

L = 6ft x 6ft (1.8m x 1.8m), Presence loop
L1 = 6ft x 6ft (1.8m x 1.8m), Presence loop (Loop L1 is optional)
L2 = 6ft x 40ft to 60ft (1.8m x 12.0) Quadruple loop

Flashers

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

11-06
<table>
<thead>
<tr>
<th>Sign No.</th>
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<th>Sign No.</th>
<th>Description</th>
<th>Graphic</th>
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</thead>
<tbody>
<tr>
<td>R1-1</td>
<td>&quot;STOP&quot; Sign</td>
<td><img src="STOP.png" alt="STOP" /></td>
<td>R3-5a</td>
<td>Through Arrow &quot;ONLY&quot; Sign</td>
<td><img src="ONLY.png" alt="ONLY" /></td>
</tr>
<tr>
<td>R1-2</td>
<td>&quot;YIELD&quot; Sign</td>
<td><img src="YIELD.png" alt="YIELD" /></td>
<td>R3-5L</td>
<td>Left Arrow &quot;ONLY&quot; Sign</td>
<td><img src="ONLY.png" alt="ONLY" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>R3-5R</td>
<td>Right Arrow &quot;ONLY&quot; Sign</td>
<td><img src="ONLY.png" alt="ONLY" /></td>
</tr>
<tr>
<td>R3-1</td>
<td>No Right Turn Sign</td>
<td>![No Right Turn]( No Right Turn.png)</td>
<td>R3-6L</td>
<td>Combined Through and Left Arrow Sign</td>
<td>![Upwards Arrow]( Upwards Arrow.png)</td>
</tr>
<tr>
<td>R3-2</td>
<td>No Left Turn Sign</td>
<td>![No Left Turn]( No Left Turn.png)</td>
<td>R3-6R</td>
<td>Combined Through and Right Arrow Sign</td>
<td>![Upwards Arrow]( Upwards Arrow.png)</td>
</tr>
<tr>
<td>R3-3</td>
<td>&quot;NO TURNS&quot; Sign</td>
<td>![NO TURNS]( NO TURNS.png)</td>
<td>R3-18</td>
<td>No U-Turn/No Left Turn Sign</td>
<td>![No U-Turn]( No U-Turn.png)</td>
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<tr>
<td>R3-4</td>
<td>No U Turn Sign</td>
<td>![No U Turn]( No U Turn.png)</td>
<td>R8-8</td>
<td>&quot;DO NOT STOP ON TRACKS&quot; Sign</td>
<td>![Do Not Stop On Tracks]( Do Not Stop On Tracks.png)</td>
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</table>

Commonly Used Signs

SIGNS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04
<table>
<thead>
<tr>
<th>Sign No.</th>
<th>Description</th>
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<tbody>
<tr>
<td>R10-6</td>
<td>&quot;STOP HERE ON RED&quot; Sign</td>
<td><img src="stop-red.png" alt="" /></td>
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<tr>
<td>R10-7</td>
<td>&quot;DO NOT BLOCK INTERSECTION&quot; Sign</td>
<td><img src="do-not-block.png" alt="" /></td>
</tr>
<tr>
<td>R10-10L</td>
<td>&quot;LEFT TURN SIGNAL&quot; Sign</td>
<td><img src="left-turn.png" alt="" /></td>
</tr>
<tr>
<td>R10-10R</td>
<td>&quot;RIGHT TURN SIGNAL&quot; Sign</td>
<td><img src="right-turn.png" alt="" /></td>
</tr>
<tr>
<td>R10-11</td>
<td>&quot;NO TURN ON RED&quot; Sign</td>
<td><img src="no-turn-red.png" alt="" /></td>
</tr>
<tr>
<td>R10-11a</td>
<td>&quot;NO TURN ON RED&quot; Sign</td>
<td><img src="no-turn-red.png" alt="" /></td>
</tr>
<tr>
<td>R10-12</td>
<td>&quot;LEFT TURN YIELD ON GREEN&quot; Sign</td>
<td><img src="left-turn-green.png" alt="" /></td>
</tr>
<tr>
<td>R10-13</td>
<td>&quot;EMERGENCY SIGNAL&quot; Sign</td>
<td><img src="emergency.png" alt="" /></td>
</tr>
<tr>
<td>R10-15</td>
<td>&quot;TURNING TRAFFIC MUST YIELD TO PEDESTRIANS&quot; Sign</td>
<td><img src="turning-traffic.png" alt="" /></td>
</tr>
<tr>
<td>R10-16</td>
<td>&quot;U-TURN YIELD TO RIGHT TURN&quot; Sign</td>
<td><img src="u-turn.png" alt="" /></td>
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<tr>
<td>R10-21</td>
<td>&quot;LEFT TURN SIGNAL YIELD ON GREEN&quot; • Sign</td>
<td><img src="left-turn-green.png" alt="" /></td>
</tr>
<tr>
<td>W25-2</td>
<td>&quot;ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN&quot; Sign</td>
<td><img src="extended-green.png" alt="" /></td>
</tr>
</tbody>
</table>

Commonly Used Signs

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

STD. NO. 8.0
Sheet 2 of 2
1) In general, lane-use control signs are not required when a vehicle must shift into a turning bay to make a turning movement (Example 1).

2) In general, lane-use control signs should be used when:
   A) Lane geometrics allow a through movement, but a mandatory turn is required (Examples 2 and 3).
   B) A lane without a turn bay ends abruptly (Example 4).
CASE 1
Locate Crosswalks from Center of Curve

CASE 2
Connect Wheelchair Ramps

Reference: Roadway Standard Drawing 1205.07

Crosswalks
SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
CASE 1

For approaches with intersection angles less than 90 degrees, place stop lines perpendicular to the centerline of the approach.

CASE 2

For approaches with intersection angles greater than 90 degrees, place stop lines parallel to the edge of the intersecting roadway.

Notes

"Intersection angle" is defined as the angle between the approach in question and the intersection roadway to the right.

Typically, place stop lines no more than 30 feet (9.1m) nor less than 4 feet (1.2m) from the nearest edge of the intersecting travel way.

For stop line locations at crosswalks, locate stop line 4 feet (1.2m) behind and parallel to the nearest crosswalk line, but not within the area of a wheelchair ramp.

Reference: Roadway Standard Drawings 1205.04 and 1205.07
Clear Zone Distances for Pole Placement

Distances are the desired minimum from the face of pole

Design Speed

<table>
<thead>
<tr>
<th>Design Speed MPH (km/h)</th>
<th>Distance from Face of Curb ft (m)</th>
<th>Distance from EOP ft (m)</th>
<th>Distance from EOP ft (m)</th>
<th>Side St. Speed MPH</th>
<th>Distance from Curb ft (m)</th>
<th>Distance from EOP ft (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤40 (64)</td>
<td>12 (3.5)</td>
<td>14 (4.0)</td>
<td></td>
<td>≤40</td>
<td>7 (2.0)</td>
<td>7 (2.0)</td>
</tr>
<tr>
<td>45-50 (72-80)</td>
<td>16 (5.0)</td>
<td>18 (5.5)</td>
<td>7 (2.0)</td>
<td>≥55</td>
<td>10 (3.0)</td>
<td>12 (3.0)</td>
</tr>
<tr>
<td>≥55 (88)</td>
<td>22 (6.5)</td>
<td>22 (6.5)</td>
<td>10 (3.0)</td>
<td>≥55</td>
<td>12 (4.5)</td>
<td>14 (4.5)</td>
</tr>
</tbody>
</table>

Note 1: When traffic signals are installed on high-speed facilities, the signal supports should be placed as far away from the roadway as practical.

Note 2: Painted islands should not be used for pole locations unless a method of protection is provided (such as a guardrail).

Reference: "Roadside Design Guide" 2002 AASHTO

Standard Pole Placement

SIGNS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04
Survey Level With Rod Method

Step 1: Using a standard Survey Level and Level Rod:
- Take elevation shots on high point of roadway (shot "A") and at proposed pole foundation centerline (Shot "B").

Find the elevation difference between the proposed foundation and the high point of the roadway
- Subtract the rod reading of Shot "A" from the rod reading of shot "B".

\[
B - A = \text{Elevation Difference}
\]

Elevation difference for Pole No. 1: \(6.92' - 4.62' = +2.3'
Elevation difference for Pole No. 2: \(2.72' - 4.62' = -1.9'

Determining Elevation Difference for Metal Poles

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 10.1.1
SHEET 1 OF 2
Total Station And Data Collector With Prism Rod Method

Step 1: Using a Total Station and Data collector with Prism Rod:
- Take elevation shots on high point of roadway (shot "A") and at proposed pole foundation centerline (Shot "B").

Step 2: Find the elevation difference between Shot "A" and Shot "B"
- Subtract the ground elevation of Shot "B" from the roadway elevation of shot "A".

Notice the difference in the equation when different survey methods are used. A positive number should reflect that you would add the elevation difference to the pole height, where a negative number would mean that you would subtract the elevation difference when determining the pole height.

\[ A - B = \text{Elevation Difference} \]

Elevation difference for Pole No. 1: 101.38' - 99.08' = +2.3'
Elevation difference for Pole No. 2: 101.38' - 103.28' = -1.9'

Determining Elevation Difference for Metal Poles

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 10.1.1

SHEET 2 OF 2
MINIMUM STRAIN POLE HEIGHT \( (H) = A + B + C - D + E + F \)

Spanwire Length \( L = 110' \)

**WHERE:**

- **A** Elevation Adjustment (See 10.1.1)
- **B** Roadway Clearance Distance (Design Height typically 17')
- **C** Signal Head Height for Spanwire Mounting (See 10.1.3)
- **D** Top of pole base above ground = 0.75'
- **E** Spanwire Sag = 4% of total Spanwire Length "L"
- **F** Spanwire Attachment Point (Minimum) = 1.5' Below Top of Pole

Calculating \( H \) (Round up to .5 ft.)

- Pole height for pole No. 1 \( (H) \): \(+2.3' + 17' + 4.25' - .75' + 4.4' + 1.5' = 28.7' \Rightarrow 29.0'\)
- Pole height for pole No. 2 \( (H) \): \(-1.9' + 17' + 4.25' - .75' + 4.4' + 1.5' = 24.5' \Rightarrow 24.5'\)

**Pole Height Determination – Strain Poles**

**SIGNALS & GEOMETRICS SECTION**

**TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH**

**NORTH CAROLINA DEPARTMENT OF TRANSPORTATION**

**STD. NO.**

7-04

**SHEET 1 OF 3**
MAST ARM ATTACHMENT HEIGHT (H1) = A + B + C - D
MAST ARM POLE HEIGHT (H2) = H1 + F

WHERE:
A = Elevation Adjustment - (See 10.1.1)
B = Roadway Clearance Distance (Design Height typically 17')
C = \( \frac{1}{2} \) Signal Head Height for Mast Arm Mounting (See 10.1.3)
D = Top of Pole base above ground = 0.75'
F = Arm Attachment Point to Top of Pole = 2'

EXAMPLES:
Calculating H1
(Round up to .1 ft.)
- Mast Arm attachment height for pole No. 1 (H1): \( +2.3' + 17'' + (4.67''/2) - .75' \) = 20.885' => 20.9 ft.
- Mast Arm attachment height for pole No. 2 (H1): \( -1.9' + 17'' + (4.67''/2) - .75' \) = 16.685' => 16.7 ft.

Calculating H2
(Round up to .5 ft.)
- Pole height for pole No. 1 (H2): 20.9' + 2' = 22.9' => 23.0 ft.
- Pole height for pole No. 2 (H2): 16.7' + 2' = 18.7' => 19.0 ft.

Pole Height Determination – Straight Mast Arms

7-04

STANDARD NO. 10.1.2
SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
Arched arms are attached at a lower point on the pole upright than straight arms are. This situation can pose a potential clearance problem for a vehicle if the structure is close to the edge of the travelway, but this can be addressed in the design of the structure.

When a metal pole with arched arms will be 6 ft. or closer to the edge of the travelway, provide the following information on the loading diagrams:

a) Provide the horizontal distance from the edge of the proposed pole to the edge of the travelway.

b) Provide the elevation difference between the edge of the travelway and the ground elevation at the proposed foundation.

With this information, the pole manufacturer can modify the rake angle or slope of the arm to ensure that the minimum roadway clearance is met at a specific point from the pole.

**Pole Height Determination – Curved /Arched Mast Arms**

**EXAMPLES:**

**Calculating H1**

- **Mast Arm attachment height for pole No. 1 (H1):** +2.3'+17'+(4.67'/2)-.75'-5.0' = 15.885' => 15.9 ft.
- **Mast Arm attachment height for pole No. 2 (H1):** -1.9'+17'+(4.67'/2)-.75'-5.0' = 11.685' => 11.7 ft.

**Calculating H2**

- **Pole height for pole No. 1 (H2):** 15.9'+2' = 17.9' => 18.0 ft.
- **Pole height for pole No. 2 (H2):** 11.7'+2' = 13.7' => 14.0 ft.
### Loading Schedule for Strain Poles

<table>
<thead>
<tr>
<th>Description</th>
<th>Area</th>
<th>Size</th>
<th>Weight</th>
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<tbody>
<tr>
<td>SIGNAL HEAD 12&quot;-3 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>9.2 S.F.</td>
<td>25.5&quot; W X 52.0&quot; L</td>
<td>56 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 12&quot;-4 SECTION (T-TYPE)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>16.3 S.F.</td>
<td>42.0&quot; W X 56.0&quot; L</td>
<td>73 LBS</td>
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<tr>
<td>SIGNAL HEAD 12&quot;-4 SECTION (VERTICAL)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>11.6 S.F.</td>
<td>25.5&quot; W X 65.5&quot; L</td>
<td>69 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 12&quot;-5 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>16.3 S.F.</td>
<td>42.0&quot; W X 56.0&quot; L</td>
<td>89 LBS</td>
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<tr>
<td>SIGNAL HEAD 8&quot;-3 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>6.3 S.F.</td>
<td>22.0&quot; W X 41.5&quot; L</td>
<td>41 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 8&quot;-4 SECTION (VERTICAL)-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>7.9 S.F.</td>
<td>22.0&quot; W X 51.5&quot; L</td>
<td>49 LBS</td>
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<td>SIGNAL HEAD 8&quot;-5 SECTION-WITH BACKPLATE, HANGER, AND BALANCE ADJUSTER</td>
<td>10.6 S.F.</td>
<td>35.0&quot; W X 43.5&quot; L</td>
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<td>SIGN WITH HANGER</td>
<td>5.0 S.F.</td>
<td>24.0&quot; W X 30.0&quot; L</td>
<td>11 LBS</td>
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<tr>
<td>SIGN WITH HANGER</td>
<td>7.5 S.F.</td>
<td>30.0&quot; W X 36.0&quot; L</td>
<td>14 LBS</td>
</tr>
<tr>
<td>SIGN LED BLANKOUT WITH HANGER</td>
<td>6.0 S.F.</td>
<td>24.0&quot; W X 36.0&quot; L</td>
<td>110 LBS</td>
</tr>
</tbody>
</table>

### Loading Schedule for Mast Arm Poles

<table>
<thead>
<tr>
<th>Description</th>
<th>Area</th>
<th>Size</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIGNAL HEAD 12&quot;-3 SECTION-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>9.3 S.F.</td>
<td>25.5&quot; W X 52.0&quot; L</td>
<td>60 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 12&quot;-4 SECTION (T-TYPE)-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>16.3 S.F.</td>
<td>42.0&quot; W X 56.0&quot; L</td>
<td>90 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 12&quot;-4 SECTION (VERTICAL)-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>11.7 S.F.</td>
<td>25.5&quot; W X 66.0&quot; L</td>
<td>74 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 12&quot;-5 SECTION-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>16.3 S.F.</td>
<td>42.0&quot; W X 56.0&quot; L</td>
<td>103 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 8&quot;-3 SECTION-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>6.4 S.F.</td>
<td>22.0&quot; W X 42.0&quot; L</td>
<td>43 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 8&quot;-4 SECTION (VERTICAL)-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>7.9 S.F.</td>
<td>22.0&quot; W X 52.0&quot; L</td>
<td>53.5 LBS</td>
</tr>
<tr>
<td>SIGNAL HEAD 8&quot;-5 SECTION-WITH BACKPLATE AND ASTRO-BRAC</td>
<td>10.6 S.F.</td>
<td>35.0&quot; W X 43.5&quot; L</td>
<td>75 LBS</td>
</tr>
<tr>
<td>SIGN RIGID MOUNTED WITH ASTRO-SIGN-BRAC</td>
<td>5.0 S.F.</td>
<td>24.0&quot; W X 30.0&quot; L</td>
<td>11 LBS</td>
</tr>
<tr>
<td>SIGN RIGID MOUNTED WITH ASTRO-SIGN-BRAC</td>
<td>7.5 S.F.</td>
<td>30.0&quot; W X 36.0&quot; L</td>
<td>14 LBS</td>
</tr>
<tr>
<td>SIGN LED BLANKOUT WITH HANGER</td>
<td>6.0 S.F.</td>
<td>24.0&quot; W X 36.0&quot; L</td>
<td>110 LBS</td>
</tr>
</tbody>
</table>
Typical Count Diagram
Complete Traffic Counts

Counts

SR 1223
3920

211
552*

SR 1223

51
48

54

211
850

124
89

8002

759
713

51
48

54

52

1256
109*

3920

211
552*

34
22

23
16

34
22

18,227

8002

558

350

45
60

45
60

113
72

113
72

8501

18,015

US 74

US 74

Elm Street

Total of all vehicles for the count period for this movement

If data on three peaks (am, noon, pm) is desired, show in this fashion

If a "noon" (between 10:30am and 2:30pm) peak occurs, show in this fashion:

Peaks

< NOON 11:30am - 12:30pm
PM 4:30pm - 5:30pm

AM 7:30am - 8:30am
PM 4:30pm - 5:30pm

am peak hour traffic for this movement
pm peak hour traffic for this movement

*Calculated by adding 16 hour totals for all movements in transit over this leg:
8501 + 250 + 601 +
552 + 8002 + 109 = 18,015
(Movements shown with asterisk)
Typical Count Diagram
Estimated Traffic Counts

Year 2020 Projected Volumes

- ADT
- Peak Hour

SR 1223
10,500

US 74
20,000

US 74
15,550

Estimated peak hour traffic for this movement

Estimated ADT for this leg

Traffic Counts

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
Conversion from Estimated ADT to Estimated DDHV - Example

**Given**
- Project Letting Date = 2000
- Design Year = Letting Date + 5 years = 2005
- D = 60%
- DHV = 10%

<table>
<thead>
<tr>
<th>ADT in hundreds</th>
<th>55</th>
<th>92</th>
<th>1996</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160</td>
<td>261</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>142</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Step 1**
Interpolate to find 2005 ADT.
- For the north leg, \(55 + (92-55)(9/20) = 72\)

**Step 2**
Convert to DDHV: \((ADT)(DHV)(D) = DDHV\).
- For the north leg, \((7200)(.10)(.60) = 432\)

**Step 3**
Determine through volumes by subtracting turning volume from total volume.
- For the north leg, \(432 - 90 - 150 = 192\)

**Step 4**
Complete count diagram.

**Notes**
- ADT = Average Daily Traffic
- DHV = Design Hour Volume
- DDHV = Directional Design Hour Volume
- D = Directional Split
- Use the highest directional split for each movement. Do not attempt to determine the direction of the peak flow for both the morning and afternoon peak hours.
- Because of the uncertainty of the data, a peak hour factor of 1.0 should be used when these peak hour volumes are used for analysis.
Recommended Treatment for Turn Lanes

Symmetrical Widening

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Posted Speed (mph)</th>
<th>Minimum Deceleration Length (D)</th>
<th>Desirable Deceleration Length (D)</th>
<th>Bay Taper Length (T)</th>
<th>Approach / Departure Taper (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>≤ 25</td>
<td>100'</td>
<td>150'</td>
<td>75'</td>
<td>$A = WS^2/60$ (IF $S \leq 40$ MPH)</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>100'</td>
<td>150'</td>
<td>75'</td>
<td>$A = WS$ (IF $S &gt; 40$ MPH)</td>
</tr>
<tr>
<td>40</td>
<td>35</td>
<td>150'</td>
<td>200'</td>
<td>100'</td>
<td>$S = $Design Speed</td>
</tr>
<tr>
<td>45</td>
<td>40</td>
<td>150'</td>
<td>250'</td>
<td>100'</td>
<td>$W = $Width of Lateral Shift</td>
</tr>
<tr>
<td>50</td>
<td>45</td>
<td>150'</td>
<td>300'</td>
<td>100'</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>50</td>
<td>200'</td>
<td>500'</td>
<td>150'</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>55</td>
<td>250'</td>
<td>575'</td>
<td>200'</td>
<td></td>
</tr>
</tbody>
</table>

*Storage length for waiting vehicles should be calculated based on the latest version of the Highway Capacity Manual or Policy on Street and Driveway Access to North Carolina Highways.*

From Policy on Street and Driveway Access to North Carolina Highways

Geometrics – Turn Lanes

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

STD. NO. 12.0
Sheet 1 of 2
Recommended Treatment for Turn Lanes

Pocket Lanes

Near Side Widening

All values to be determined using the table on the previous page.

From Policy on Street and Driveway Access to North Carolina Highways

Geometrics – Turn Lanes

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation
2070L Preemption Chart

Used to designate this interval as the preemption dwell interval. This interval will use Dwell Min. Time below. Selecting 255 sec. green indicates dwell (hold) phase.

Clearance times for dwell (hold) phase. Using 0.0 sec. for each will allow controller to use times set in normal operation.

Amount of time signal is in exit phase before preemption ends. Select 0 for controller to return to normal operation after preemption. Select 1 to designate an exit phase.

Clearance time not used when Interval 5 is exit interval.

Delay time after preempt call is received before going to preempt phase. Usually 0.0 sec. for Opticom systems; may need delay for pushbutton locations.

Minimum green time assured for current phase before transitioning into preempt phase. Usually 1 sec., so as to begin preemption sequence immediately (0 sec. will default to normal minimum green time).

Time provided to display Flashing "DON'T WALK" for pedestrians to clear intersection before beginning preemption sequence.

Clearance times provided to clear current phase before transitioning into preemption. Using 0.0 sec. for each will allow controller to use times set in normal operation.

Minimum time preemption dwell phase will run. Opticom systems typically use the same time as the phase in normal operation. Minimum time for pushbutton locations needs to be based on trial runs (typically by the Division).

Select yes to clear to all red before going into preemption to prevent yellow trap.

"Y" (for Yes) will time the "Ped Clear Before Pre" and "Yellow Clear Before Pre" simultaneously, thereby reducing overall clearance time needed before preemption. Select "N" to time "FDW" and then yellow clear and red clear before going into preemption.

Time to extend preempt dwell phase after call is dropped (usually 2 sec.) Prevents the call from being dropped accidentally. Typically used for Opticom systems.

### 2070L EV PREEMPTION

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>PRE 3</th>
<th>PRE 4</th>
<th>PRE 5</th>
<th>PRE 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval 1 – Dwell Green</td>
<td>255</td>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Interval 1 – Dwell Yellow</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
</tr>
<tr>
<td>Interval 1 – Dwell Red</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
</tr>
<tr>
<td>Interval 5 – Exit Green</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Interval 5 – Yellow</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Interval 5 – Red</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Delay Time</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Min Green Before Pre</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Ped Clear Before Pre</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yellow Clear Before Pre</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
</tr>
<tr>
<td>Red Clear Before Pre</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
<td>0.0*</td>
</tr>
<tr>
<td>Dwell Min Time</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Enable Backup Protection</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Ped Clear Through Yellow</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Preempt Extend**</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

* Time defaults to time used for phase during normal operation
** Program Timing on Optical Detection Unit

Notes:
1) For pushbutton operation, use EV PRE 2.
2) For Opticom type operation:
   - For 1 preempt, use EV PRE 3
   - For 2 preempts, use EV PRE 3 and 5
   - For 3 preempts, use EV PRE 3, 4, and 5
   - For 4 preempts, use EV PRE 3, 4, 5, and 6
3) Include corresponding regular phases in phasing diagram

Emergency Vehicle Preemption

Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

7-05

STD. NO. 13.0

Sheet 1 of 2
### NEMA Preemption Chart

Delay time after preempt call is received before going to preempt phase. Usually 0 sec. for Opticom systems. May need delay for pushbutton locations, typically Division will determine delay needed.

Time provided to display Flashing "DON'T WALK" for pedestrian to clear intersection before beginning preempt sequence. This time may be reduced if necessary.

Minimum green time assured for current phase before transitioning into preempt phase. Usually 1 sec., so as to begin preempt sequence immediately (0 sec. will default to normal minimum green time).

Highest yellow and highest red clear times needed to clear normal operation phases (may come from different phases).

Minimum time preemption dwell phase will run. Opticom systems typically use the same time as the phase in normal operation. Minimum time for pushbutton locations needs to be based on trial runs (typically by the Division).

Clearance times for dwell (hold) phase. Use clearance times from corresponding normal phase (See Std. 5.2.2, Sheet 4).

Some NEMA controllers allow Ped Clear time and Yellow Clear time Before Preempt to time simultaneously, while other brands do not. If in doubt about type of equipment being used, select "N."

Time to extend preempt dwell phase after call is dropped (usually 2 sec.) Prevents the call from being dropped accidentally. Typically used for Opticom systems.

#### NEMA EV PREEMPTION

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>PRE 3</th>
<th>PRE 4</th>
<th>PRE 5</th>
<th>PRE 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Before Preempt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ped Clear Before Preempt</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Min. Green Before Preempt</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Yellow Clear Before Preempt</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Red Clear Before Preempt</td>
<td>1.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Preempt Dwell Min. Green</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Yellow Clr After Preempt</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Red Clr After Preempt</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Ped Clear Through Yellow</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
<td>Y/N</td>
</tr>
<tr>
<td>Preempt Extend**</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Notes:**
1) For pushbutton operation, use EV PRE 2.
2) For Opticom type operation:
   - For 1 preempt, use EV PRE 3
   - For 2 preempts, use EV PRE 3 and 5
   - For 3 preempts, use EV PRE 3, 4, and 5
   - For 4 preempts, use EV PRE 3, 4, 5, and 6
3) Include corresponding regular phases in phasing diagram

---

### 170 Preemption Chart

Time needed for pedestrians to clear intersection before going into preempt phase.

Preemption dwell phase minimum green (times after call is released).

---

### 170 EV PREEMPTION

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>EVA</th>
<th>EVB</th>
<th>EVC</th>
<th>EVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Before Preempt</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ped. Clear Before Preempt</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Min. Green Before Preempt</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Clearance Time</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Preempt Extend**</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Notes:**

**Program Timing on Optical Detection Unit**

---

### Emergency Vehicle Preemption

**Signals & Geometrics Section**

Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

7-04
NOTE: BLANKOUT SIGNS ARE NOT USED IN CONJUNCTION WITH "YIELD" SIGN CONTROLLED MOVEMENTS.

Use of Signal Heads and Blankout Signs
Permissive Only Displays

Track Clearance Display

A No Left Turn Blankout Sign
B Yield Sign (R1-2)
C "ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN" Sign (W25-2)

Railroad Preemption

STD. NO. 13.1

TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04
Use of Signal Heads and Blankout Signs
Protected /Permissive Displays

Track Clearance Display

No Right Turn Blankout Sign
No Left Turn Blankout Sign
"ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN" Sign (W25-2)

Railroad Preemption
SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04

STD. NO.
13.1

SHEET 2 OF 10
Use of Signal Heads and Blankout Signs
Protected Only Displays

NOTE: BLANKOUT SIGNS ARE NOT USED IN CONJUNCTION WITH "RED ARROW" SIGNAL DISPLAYS

Railroad Preemption
SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

STD. NO. 13.1
7-04
SHEET 3 OF 10
Use of Signal Heads and Blankout Signs
Advance Signal Heads
(With Adequate Storage)

Design Consideration:
When active crossing warning devices consists only of flashers (no gates present) and there is room to store vehicles between the tracks and the intersection.

Advance signal faces should be located as near as practical to the stop line.

Advance signal heads should not block or obstruct flashers on cantilever (if used).

Adequate storage space to hold at least one design vehicle (typically assumed to be 20').

NOTE: Based on engineering judgement, advance signal heads may be placed downstream (across) of the railroad tracks.

NOTE: When advance heads are used, consider visibly limiting the signal heads for the approach from the railroad at the intersection.

Railroad Preemption

SIGNALS & GEOMETRICS SECTION
TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

7-04
Use of Signal Heads and Blankout Signs
Advance Signal Heads
(Without Adequate Storage)

Design Consideration:
When there is no room to store vehicles between the tracks and the intersection.

A Track Clearance Phase is generally not used in this situation.

A supplemental signal head should be used due to the potential for a train to block the signal heads.

Traffic must stop at stopbar prior to railroad track for signal. A "NO TURN ON RED" sign should be used.

Advance signal heads should not block or obstruct flashers on cantilever (if used).

A supplemental signal head may be needed due to the potential for a train to block the signal heads.

SIGN I.D.
A "NO TURN ON RED" Sign (R10-11)
B "STOP HERE ON RED" Sign (R10-6)
C "DO NOT STOP ON TRACKS" Sign (R8-8)
Greenshield's Formula:

Track Clearance Green = 4 + 2(n/d), where:

- \( n \) = distance between stopbars
- \( d \) = assumed length of design vehicle (20')

Stopbars are usually located by Rail Division.

Round Track Clearance Green time up to the nearest whole number.
(i.e. 14.6 sec. \( \rightarrow \) 15 sec.)
# 2070L Preemption Chart

Based on Greenshield's Formula (see Sheet 6).

Typically minimum is 10 seconds.

Times for track clearance phase. Should be the same times as if the phase were used in normal operation.

Used to designate this interval as the preemption dwell interval. This interval will use Dwell Min. Time below. Selecting 255 sec. green indicates dwell (hold) phase.

Clearance times for dwell (hold) phase. Using 0.0 sec. for each will allow controller to use times set in normal operation.

Amount of time signal is in exit phase before preemption ends. Select 0 for controller to return to normal operation after preemption. Select 1 to designate an exit phase.

Clearance time not used when Interval 5 is exit interval.

Delay time after preempt call is received before going to preemption sequence. Typically use 0 sec.

Minimum green time assured for current phase before transitioning into preemption phase. Usually 1 sec., so as to begin preemption sequence immediately (0 sec. will default to normal minimum green time).

Time provided to display Flashing "DON'T WALK" for pedestrians to clear intersection before beginning preemption sequence. This time may be reduced if necessary.

Clearance times provided to clear current phase before transitioning into preemption. Using 0.0 sec. for each will allow controller to use times set in normal operation.

Minimum Green Time for Dwell (hold) phase. Typically, same as time used in normal operation.

"Y" (for Yes) will time the "Ped Clear Before Pre" and "Yellow Clear Before Pre" simultaneously, thereby reducing overall clearance time needed before preemption. Select "N" to time "FDW" and then yellow clear and red clear before going into preemption.

### 2070L RR Preemption

| Interval 1 - Track Clearance Green          | 12 |
| Interval 1 - Track Clearance Yellow        | 3.7 |
| Interval 1 - Track Clearance Red           | 1.8 |
| Interval 2 - Dwell Green                   | 255 |
| Interval 2 - Dwell Yellow                  | 0.0* |
| Interval 2 - Dwell Red                     | 0.0* |
| Interval 5 - Exit Green                    | 1  |
| Interval 5 - Yellow                        | 0.0 |
| Interval 5 - Red                           | 0.0 |
| Delay Time                                 | 0  |
| Min Green Before Pre                       | 1  |
| Ped Clear Before Pre                       | 0  |
| Yellow Clear Before Pre                    | 0.0* |
| Red Clear Before Pre                       | 0.0* |
| Dwell Min Time                             | 7  |
| Ped Clear Through Yellow                   | Y/N |

*Time defaults to time used for phase during normal operation

---

**Notes:**
1. Use Preemption 1
2. Include corresponding regular phases in phasing diagram

---

**Railroad Preemption**

<table>
<thead>
<tr>
<th>SIGNALS &amp; GEOMETRICS SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAFFIC ENGINEERING AND SAFETY SYSTEMS BRANCH</td>
</tr>
<tr>
<td>NORTH CAROLINA DEPARTMENT OF TRANSPORTATION</td>
</tr>
</tbody>
</table>

**STD. NO.**

13.1

**SHEET**

7 OF 10
NEMA (TS-1 and TS-2) Preemption Chart

Delay time after preemption call is received before going into preemption sequence: Typically use 0 sec.

Time provided to display Flashing "DON'T WALK" for pedestrian to clear intersection before beginning preemption sequence. This time may be reduced if necessary.

Minimum green time assured for current phase before transitioning into preemption phase. Usually 1 sec., so as to begin preemption sequence immediately (0 sec. will default to normal minimum green time).

Highest yellow and highest red clearance times needed to clear normal operation phases (may come from different phases).

Based on Greenshield's Formula (see Sheet 6).

Times for Track Clearance phase. Should be the same times as if the phase were used in normal operation (See Std. 5.2.2, Sheet 4).

Min Green Time for Dwell (hold) phase. Typically same as time used in normal operation.

Yellow and Red Times of Dwell (hold) phase. Use highest yellow and red times if more than 1 Dwell phase is used.

Some NEMA controllers allow Ped Clear time and Yellow Clear time Before Preempt to time simultaneously, while other brands do not. If in doubt about type of equipment being used, select "N."

<table>
<thead>
<tr>
<th>NEMA RR PREEMPTION 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Before Preempt</td>
<td>0</td>
</tr>
<tr>
<td>Ped. Clear Before Preempt</td>
<td></td>
</tr>
<tr>
<td>Min. Green Before Preempt</td>
<td>1</td>
</tr>
<tr>
<td>Yellow Clear Before Preempt</td>
<td></td>
</tr>
<tr>
<td>Red Clear Before Preempt</td>
<td></td>
</tr>
<tr>
<td>Track Clearance Green</td>
<td></td>
</tr>
<tr>
<td>Track Clearance Yellow</td>
<td></td>
</tr>
<tr>
<td>Track Clearance Red</td>
<td></td>
</tr>
<tr>
<td>Preempt Dwell Min. Green</td>
<td></td>
</tr>
<tr>
<td>Yellow Clear After Preempt</td>
<td></td>
</tr>
<tr>
<td>Red Clear After Preempt</td>
<td></td>
</tr>
<tr>
<td>Ped Clear Through Yellow</td>
<td>Y/N</td>
</tr>
</tbody>
</table>

Notes:
1) Use Preemption 1
2) Include corresponding regular phases in phasing diagram

Railroad Preemption

Signals & Geometrics Section
Traffic Engineering and Safety Systems Branch
North Carolina Department of Transportation

STD. NO. 13.1
Sheet 8 of 10
170 Preemption Chart

Delay time after preempt call is received before going into preempt sequence: Typically use 0 sec.

Based on Greenshield's Formula (see Sheet 6).

### 170 RAILROAD PREEMPTION

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay Before Preempt</td>
<td>0</td>
</tr>
<tr>
<td>Track Clearance Green</td>
<td>–</td>
</tr>
</tbody>
</table>

**NOTE:** The Railroad preemption calls are immediate with 170 equipment. 170 Bi-Trans Software does not clear pedestrian times before entering Railroad Preemption. Ped displays go directly from a solid WALK to a solid DON'T WALK display and does not provide any clearance time (flashing DON'T WALK display).
Elements on a Signal Plan with Railroad Preemption

- AAR DOT Crossing Number on Plan.
- Name of Railroad(s) operating on tracks.
- Show all gates, flashers, and cantilevers on signal plan.
- Railroad Preemption Timing Chart.
- Be sure all phases (including any timed overlaps) lead directly to a Track Clearance phase.
- Railroad Preemption should have priority over Emergency Vehicle Preemption.
- "NO RIGHT (LEFT) TURN" Blankout signs as needed.
- Show blankout signs in Table of Operation. Illuminate blankout signs during track clearance and all preempt hold phases.
- Include blankout sign operation during flash mode in the Notes.
- When entering the preemption sequence, yellow traps are permitted if necessary to provide immediate and proper track clearance. Use an "ONCOMING TRAFFIC MAY HAVE EXTENDED GREEN" sign (W25-2) on the approach(es) subjected to a yellow trap.
- Use a "DO NOT STOP ON TRACKS" sign (R8-8) on approach crossing tracks leading to signal (add any other time there is potential for traffic to queue across tracks).
- Use a "STOP HERE ON RED" sign (R10-8) if traffic is to stop prior to tracks and there is little or no storage room between tracks and the intersection.
- When possible, the street crossing the tracks should flash YELLOW in flashing operation, even if it is not the main phase (2+6). If the side street flashes yellow, then the main street flashes red. An all red flashing indication may also be used at some locations.
- 2070 and most NEMA equipment can designate an exit phase upon leaving Railroad Preemption. Typically, exit to the primary phase that was unable to move due to the presence of a train.

Elements for Calculating Minimum Advance Warning Time

- Delay Before Preempt
  * Ped Clear Before Preempt
  * Min Green Before Preempt
  * Yellow Clear Before Preempt
  * Red Clear Before Preempt
  * Track Clear Green
  ** Track Clear Yellow
  ** Track Clear Red
  ** Time for Exit Gates

Safety Equipment Reaction Time
(Usually 5 Seconds)

Add the above to find the Advance Warning Time needed to clear signal for preemption and request this time from Rail Division.

* These values may clear simultaneously with some types of signal equipment.

** If 4 quadrant (exit) gates are used, do not include Track Clear Yellow and Track Clear Red times in this equation. Instead add:
  12 Seconds for exit gates to descend to horizontal position.
  5 seconds (exit gates should be horizontal 5 seconds prior to train arrival).
Design Considerations

The purpose of system detectors is to provide volume and occupancy information for dynamic traffic control.

More advanced equipment allows for independent control of multiple zones in the same system, so each system must be evaluated to determine its logical segments. (a.k.a. zones)

Subject to the noted limits, enough system detectors should be included to provide redundant detection of main and side street traffic in each zone of the system:

. Main street detection should be provided in each direction at multiple intersections in each zone.
. Side street detection should be provided at critical intersections in each zone and at additional locations when combined loops are possible and system detector limits are not compromised.

Design Engineer should consult with system timing group to determine ultimate system detector locations.

System Detector Limits

- 2070 Systems:
  . Each master controller is limited to 64 system detectors.
  . Each local controller is limited to 16 system detectors.

- NEMA TS-1 and TS-2 Systems:
  . Each master controller is limited to 32 system detectors.
  . Each local controller is limited to 8 system detectors.

- Other Considerations:
  . Pole-mounted cabinets frequently have limited rack space for detectors, which may limit the number of system detectors.
  . Keep some system detectors in reserve for future signal addition and/or addition of system detectors based on field experience.
Combined System and Main Street Detectors

System Detectors with Volume-Density Operation

Design Considerations:
- Preferred treatment for new 2070 system installations.
- Typically for use with D>=300' (90m).
- Loop size, turns, and location based on Main Street detection.
- Set detectors to presence mode.
- Any delay or stretch (carry) times must be programmed in the controller, not on the detector unit (may not be possible in older controllers, especially NEMA TS-1).
- Combined loops must be wired to separate detectors/channels.
- With Volume-Density operation, combined loops can be used with or without DC/EC.
- Not for use with low speed detection.

System Detectors with Stretch Operation
Downstream Main Street System Detectors

Design Considerations:
- Preferred for consistency at signals in existing systems with downstream system detectors, especially older NEMA systems.
- May also be appropriate in new systems at locations with heavy undetected turns from the side street to the main street (where side street system detectors are not appropriate).
- Set detectors to presence mode.
- Locate downstream system detectors past the point where traffic has selected a lane while also avoiding driveways.

- SD = 6ft X 6ft, (1.8m X 1.8m)
  Wired to separate channels

- D = 50-250’ (15m-75m) beyond intersection
Combined System and Side Street Detectors

SDs with Volume-Density or Stretch Operation

When to use combined loops

Design Considerations:
- Side street system detectors should be provided when combination loops are possible, provided system detector limits are not compromised.
- Combined system detectors are NOT preferred when loop placement is past the entrance to the left or right turn lane (when combined system detectors will miss traffic turning onto the main street - see figure).
- Typically for use with D≥300' (90m).
- Loop size, turns, and location based on side street detection.
- Set detection to presence mode.
- May not be possible in older controllers, especially NEMA TS-1.
- Combined loops must be wired to separate detectors/channels.

Closed Loop Signal Systems – Side Street Detection

7-04

14.2
Upstream Side Street – System Detectors

Design Considerations:

- When combination loops are not possible or not preferred, this treatment may be used at the critical intersection in each zone of new system installation.
- Set detectors to presence mode.
- D should be chosen to ensure all volume is counted before entering left or right turn lanes.
- If turn lane consideration makes D unreasonably large, consider placing a system detector in the turn lane (preferred) or using downstream main street system detectors at this location (less preferred).

SD = 6ft X 6ft, (1.8m X 1.8m)
Wired to separate channels

D = 300'-500', (90m-150m)